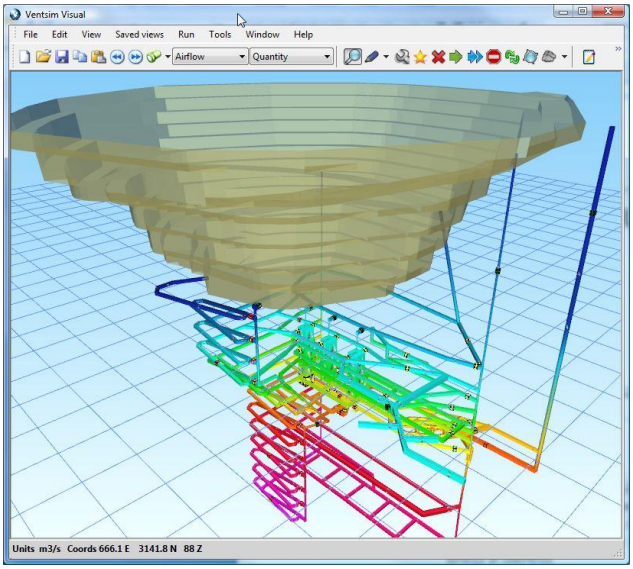
Ventsim software

Ventsim Visual™

Standard and Advanced Versions

VENTSIM SOFTWARE

Ventsim Visual™ User Guide



Volume 1 Version 1.3.

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PREFACE

This manual presents a guide to the effective use of Ventsim Visual™ ventilation software for mine ventilation simulation and design. It does not profess to be a ventilation engineering guide and as such should not be used as a substitute for existing ventilation texts for underground ventilation and environmental engineering.

The manual may contain simplifications and does not attempt to explain many of the complex concepts and methods used in mine environmental engineering. It is highly recommended that users of Ventsim Visual™ have at least a basic understanding of ventilation and simulation concepts in order to correctly input and interpret the program functions and results. Many excellent texts and papers exist for mine ventilation, not the least which is the late Malcolm J McPherson's 'Subsurface Ventilation and Environmental Engineering', from which Ventsim Visual™ draws much as the methodology for thermodynamic simulation.

Finally, special thanks to Dr Rick Brake for his assistance during the development of Ventsim Visual.

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Chapter 1

Chapter 1 Ventsim Visual™ – An Introduction

Ventsim Visual™ is a technical successor to Ventsim Classic 3.9 which was first developed and released in 1993, and was widely lauded for its simple interface and 3D wireframe approach to displaying ventilation networks.

The relatively recent introduction of affordable 3D graphics hardware into everyday PC's encouraged a new approach with Ventsim ventilation software.

It became clear soon after the introduction of Ventsim that very sophisticated and complex networks were being developed with the program, however the application and analysing of these networks was restricted by the shear amount of data being manipulated. In addition, in networks of many thousands of airway branches, serious mistakes could often be made in the entry of data without being noticed. Viewing and editing of large datasets was becoming increasingly problematic, and use of these networks by others not familiar with the network was becoming more difficult.

In general, the observation was that many sophisticated ventilation networks were being developed by bright engineers, but then simply gathered dust once these engineers moved on, and new engineers abandoned trying to decipher them.

Another key factor to the development of the next generation of Ventsim was the increasing demand to simulate and design underground environmental conditions, suitable for mine workers and equipment.

As a result, Ventsim Visual™ Standard and Advanced were developed to address these requirements. Primarily, it has been designed as a ventilation tool, which can operated independently of other mine planning packages, but maintains a level a compatibility which ensures data from mine planning packages and other ventilation software can be passed to the program.

Ventsim Visual™ provides a full toolbox of tightly integrated utilities to analyse ventilation flows, heat, contaminants and financial aspects of mine ventilation. Building on the success and experience of fifteen years of Ventsim implementation at over 400 sites, Ventsim Visual™ goes a generation further in its approach to ventilation simulation and analysis, and sets a new standard in ventilation software design and implementation.

1.1 About Ventsim Visual™

Ventilation has been a primary concern in underground mines for hundreds of years, but until the introduction of computerized network analysis in the last 40 years, the planning and modelling of ventilation was largely a black art, relying on experience, guesswork and extensive calculations.

Even when computer ventilation software allowed simulations of large networks of underground airways, the process of entering and interpreting results still remained a job for experts in the field. Ventsim Visual™ aims to make ventilation simulation and design accessible to any mine engineer or ventilation officer, even those without substantial ventilation experience.

Ventsim Visual™ Standard provides the user with the tools to;

- Simulate and provide a record of flows in an existing mine.
- Perform 'what if' simulations for planned new development.
- Help in short term and long term planning of ventilation requirements.
- Assist in selection of types of circuit fans for mine ventilation.
- Assist in financial analysis of ventilation options.
- Simulate paths and concentrations of smoke, dust, or gas for planning or emergency situations

Ventsim Visual™ Advanced provides additional tools to;

- Undertake full thermodynamic analysis of heat and refrigeration in underground mines.
- Take into account air compressibility for deeper mines.
- Provide tools for analysing multiple different airways size options, both financially and for establishing ventilation capacity.
- Provide a tool to check for recirculation in mines.
- Simulate Diesel Particulate Matter (DPM) concentrations through a mine.

Ventsim Visual™ has been written to make the process of ventilation network analysis as easy to use as possible. Both versions utilise sophisticated 3D graphics, driven by a fully graphical mouse driven interface. Ventsim Visual™ is compatible with Microsoft Windows XP or VISTA. The software can also be run on Apple Mac Computers with suitable graphics hardware, running Windows under dual boot emulation.

Chapter 2

Chapter 2 Ventsim Classic 3.9 to Visual Guide

Ventsim Visual™ is a substantially different program than Ventsim Classic 3.9 and takes a new approach to ventilation display and simulation. This section will give you a brief overview of the major changes if you are familiar with Ventsim Classic 3.9, and may also assist if you are familiar with other ventilation software packages.

2.1 Display

Ventsim Visual™ default uses a 3D perspective view.

Three dimensional (3D) perspective views are rarely used in CAD or Mine Planning packages, except occasionally for final presentation purposes. The perspective view tends to distort distances and true directions and is therefore largely unsuitable for detailed engineering drawing. An orthogonal non-perspective view however is not required for ventilation modelling, which relies more on effective data presentation.

The Ventsim Visual™ Approach
To create a user friendly, graphically rich program and interface, which shows the maximum amount of relevant data, in the most efficient and understandable way.

A 3D perspective view is the way we look at the world and when used to view computer models, it is natural and easily understood, particularly to someone unfamiliar with your network.

Airway solids shown with true dimensions and shapes allow quick appraisal to check whether dimensions are as intended. The author has found numerous examples of Ventsim Classic 3.9 networks loaded in Ventsim Visual™ that immediately show inadvertent incorrectly sized or shaped airways which may prevent the network from simulating or balancing as expected.

A perspective view also permits closer visualisation of specific parts of a network, while other parts are hidden or obscured by distance. In cluttered large networks this can help clarify intended data significantly.

2.2 Animation

They say a picture is worth a thousand words. Animation may therefore be worth a thousand pictures. Ventsim Visual™ animation again demonstrates a key feature of the software's presentation of complex data. By animating flow arrows, fans and heating/cooling sources, Ventsim Visual™ can show a huge amount of data in a way that the human brain can quickly visualise and interpret. Animated flows show the direction and relative speed of all airflows in a mine over potentially thousands of airways. Animated fans show whether they are turned on or off, while dynamic colouring draws the user's attention to specific data ranges. Using only animation and colouring of data, Ventsim Visual™ users can process and analyse complex networks, without having to interpret a single line of textual data. In addition, it makes presentation of data very effective to the layperson (who often control budgets and have to make decisions regarding investing in costly ventilation infrastructure)

2.3 Elevation Database (Levels)

There no longer needs to be a surface level elevation. Any airway can be connected to the surface at any place in the mine, by clicking on **Connect to Surface** in the airway **Edit Box**. Ventsim Visual™ will calculate which end is connected to the surface, based on simulated airflows in the mine.

A level database, although still useful, is no longer mandatory for viewing different elevations of a network. While an overarching single elevation level covering all elevation ranges is still recommended, *any* elevation range can be viewed at *any* time by ***Right Clicking*** the screen, choosing **Select Level** from the context menu, and then clicking or fencing the area you wish to view.

Once selected, ***Right Click*** to view the results. In addition the select level function can be used to quickly limit an elevation range, or multiple ranges.

2.4 Airways

Airways no longer need to be connected to another and can be left open ended, as would be the case in blind development headings. Because this may still cause unintentional problems (such as airways not joined as the user intends), Ventsim Visual™ will alert the user to these during simulation.

These warnings can be turned OFF in the **settings menu**, or disabled individually by clicking **Allow Open End** in the edit box. No airflow will travel through open ended airways, unless connected to surface.

No Entry / No Exit errors are largely abolished with Ventsim Visual™. Providing the airways are connected to a part of a network where a pressure can be derived, Ventsim Visual™ will automatically reverse and adjust airways into a node.

Finally, airways drawn by the user that cross other airways, will automatically have a junction node inserted, joining both airways.

2.5 Data

The single biggest change to Ventsim Visual™ is the visual management of data types. Around seventy (70) different data types exist in the ***Advanced*** version, all of which may be displayed as text on the screen, in a spreadsheet or as a colour range.

2.5.1 Colour and Data Manager

This creates a rich, but potentially confusing interface. To simplify things, Ventsim Visual™ uses both a **Colour Manager** and a **Data Manager** control form to assist in rapid analysing and changing of on screen data. These two controls can be utilised via the **view** menu, or from the toolbar.

It is important to note that the **Colour Manager control** can display data independently of the text data which is shown on screen (for example pressures can be showed at a colour range, while text data could show air flows. Colour ranges can be adjusted *in* the **Colour Manager control** with the slider bars, or by manually entering new ranges.

2.6 Coordinates

Ventsim has switched to a more conventional Eastern / Northing / Elevation coordinate approach. The relative directions on screen of these coordinates can be changed in the **Settings** menu.

Ventsim Visual™ allows decimal point coordinates to be used allowing more accurate placement of airways. While this will have little effect on ventilation flows, it removes the 'saw tooth' effect often seen in the Ventsim Classic 3.9 integer coordinate display

2.7 Editing and Information

2.7.1 The Edit Box

The **Edit Box** now acts as a powerful editing and information tool for airways in a network. The **Edit Box** may be left open permanently, and will update with information from the airway clicked on during viewing, editing and adding modes.

2.7.2 The Information Tab

To view airway information for example, leave the **Edit Box** selected on the **Information Tab**, and airways throughout a network can be quickly analysed by clicking on the airway. Likewise, the **Fan Tab** could be left open, and operating fan curves can be analysed quickly at different point in the network in the same way.

2.7.3 Modifying Data

To modify data in an airway, simply click on the cell you wish to modify and change the data. The airway will automatically update when Apply or OK is pressed, or when another airway is selected. Multiple airways can be selected for simultaneous editing by fencing or selecting the airways while in **Edit Mode**, and then clicking on any selected airway. Any data within the **Edit Box** changed during editing multiple airways will be changed for all the selected airways.
For example, if all selected airways require a width of 6m, then after changing and applying the **Width** in the **Edit Box**, the width (and only the width) of the selected airways would change. All other attributes (even if different between the selected airways) remain unchanged. Data that will be changed turns **blue** after modification.

To abandon these changes, select *Cancel* from the **Edit Box** before moving to another airway.

2.8 Referenced Graphics

The introduction of Ventsim Visual version 1.2 permits the use of referencing into the program of external 3D graphics DXF models, such as surface terrains, orebodies, actual development and mine infrastructure.

While referenced graphics do not interact directly with ventilation circuits, they provide a useful visual and construction aid to developing and presenting networks. Mine ventilation network airways and sizes can be directly compared to actual or design development, surface terrains can be used to ensure shafts are set to the correct elevation, while orebodies and stopes can be used to ensure ventilation circuits are not developed in the wrong area, and have adequate ventilation designs to control airflow.

2.9 Experiment !

Finally, by all means experiment with the program. Load up and view some of the included demos. Most features have a *Tool Tip* attached to them, which will provide further information if the mouse cursor is hovered near them. Ensure you save your network files frequently and create backups where necessary.

Good Luck

Craig Stewart

Author Ventsim Visual™

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Chapter

3

Chapter 3 The View Window

Ventsim Visual™ operates in a full three dimensional (3D) perspective driven environment.

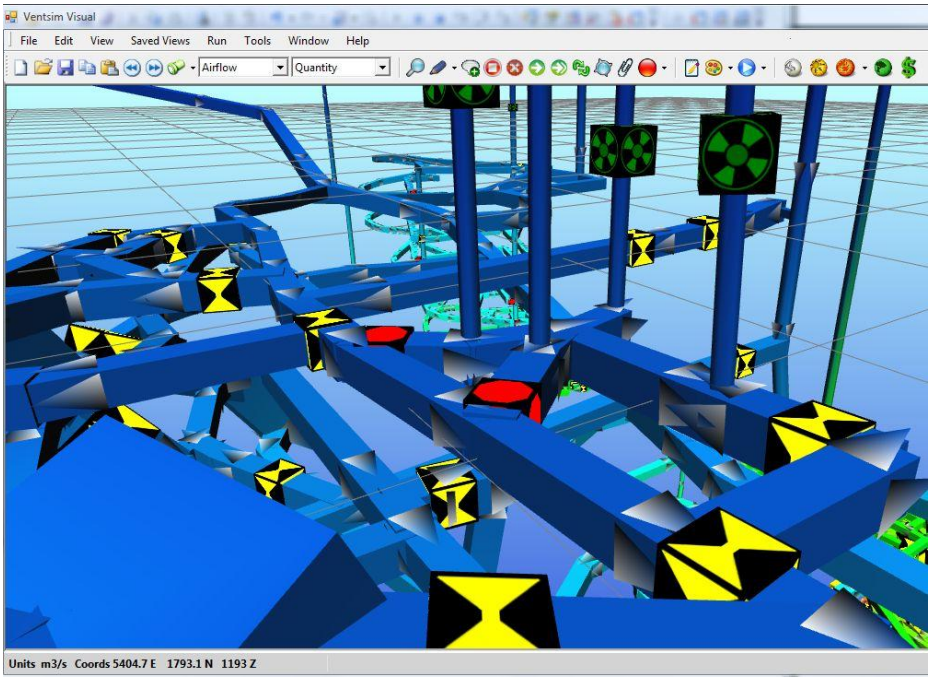


Figure 3-1 Ventsim Visual™ Main Window

The success on how to utilise some of the unique aspects of a 3D perspective view comes from an understanding of how it works. Ventsim Visual™ has a number of guides to assist in viewing and construction in 3D.

3.1 Point of Focus

The view is essentially a view seen from a 'camera' floating in space, aimed at a *point of focus*. Your eye is the camera. The point of focus is always in the centre of the screen, at a pre-determined distance away from the camera.

You can move closer or further away with the *Mouse Scroll* button, and rotate around this point of focus with the *Mouse Right* button, but you cannot move the camera past the point of focus, or to the left or right, unless you move the point of focus.

There are several ways to move the point of focus;

Draw a window with the mouse around the area you wish to focus on. The focus will move to the centre of the window, at the closest distance of an object or airway in the window.

Drag (pan) the screen with the ***Centre*** mouse button. The point of focus will move along the current horizontal plane with the mouse cursor

Click on an airway, with the ***Mouse Middle*** button (or a ***Right/Left*** combination for those without a 3 button mouse). This will automatically put the focus onto the clicked airway *at the same viewing distance as was previously set.* If the object being clicked is a long way away, this has the effect of quickly flying through space towards that object in order to maintain the same view distance as the previous point of focus.

The ***Elevation*** of the point of focus can also be changed by selecting the ***Shift*** key while using the ***Mouse Scroll*** button. A ***transparent grid*** (if the grid is turned on) will show the horizontal plane of the point of focus.

3.2 User Control Summary

Middle Mouse Button Wheel

Scroll
Zoom in / out of model

Scroll + Shift
Move Edit Plane Elevation up or down

Hold & Drag
Pan or move model about

Click
Centre model at mouse cursor

Note the combined LEFT /RIGHT mouse button can be used to simulate middle button

Right Mouse Button

Hold & Drag Up Down
Tilt Model

Hold & Drag Left / Right
Spin / Rotate Model

Click
Show Popup Menu

Left Mouse Button

View Mode

Click
Centre model at mouse cursor

Double Click
Edit airway at mouse cursor

Hold and Drag
Fence view and zoom into fenced area

Other Modes

Hold and Drag
Fence Select airways inside

Click
Activate Function

KEYBOARD COMMANDS

<ESC> :	Exit Function
<ESC> x 2:	Exit Function and return to View Mode
<SHIFT>	Move cursor in 3D vertical direction
<BSPACE>	Undo last action
<TAB>	Redo last action
<F2>	Plan / Section View Toggle
<F3>	Find airway
Others	See manual Appendix E for other commands

3.3 The Edit Plane

The ***Edit Plane*** is a horizontal plane at a set elevation. By default, any new airways are initially constructed on the edit plane. The edit plane can be viewed by ensuring the **grid** function is turned on. The plane will be crossed with grid coordinate lines. If ***Shift*** is selected the edit plane will be made semi-transparent which will indicate where it intersects existing airways.

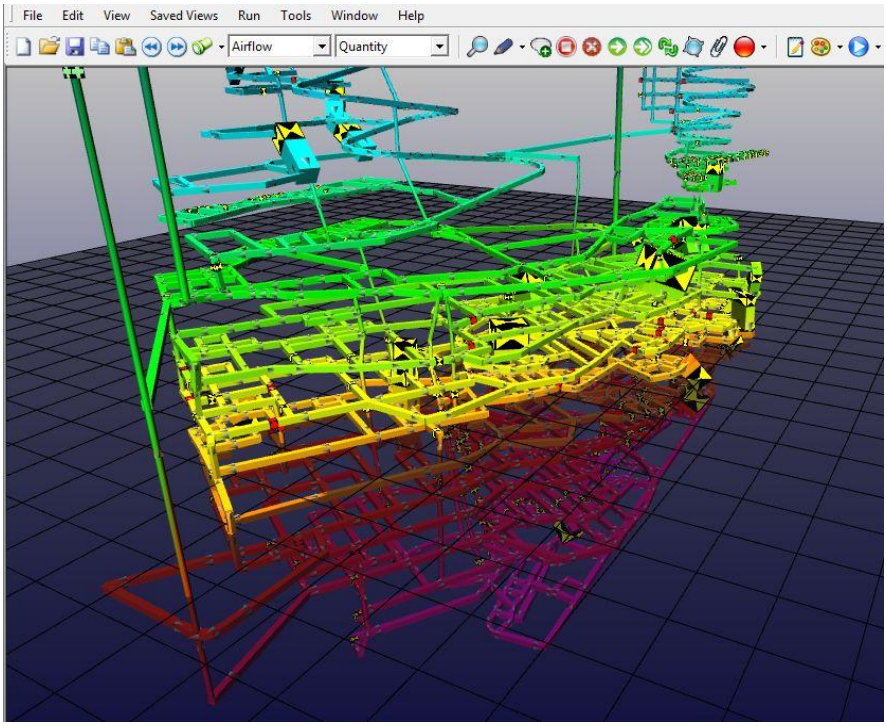


Figure 3-2 The Edit Plane, shown with the SHIFT key pressed

To move an edit plane, select a new point of focus, or use the ***Shift-Mouse-Scroll*** function described above. The coordinates in the status bar at the ***Bottom Left*** corner will always show the elevation of the edit plane.

> Hint : The Edit Plane will also temporarily move automatically to the level of an airway being drawn from another airway. Additionally, the edit plane and point of focus can be moved manually by the **Set Edit Plane** function in the menu bar.

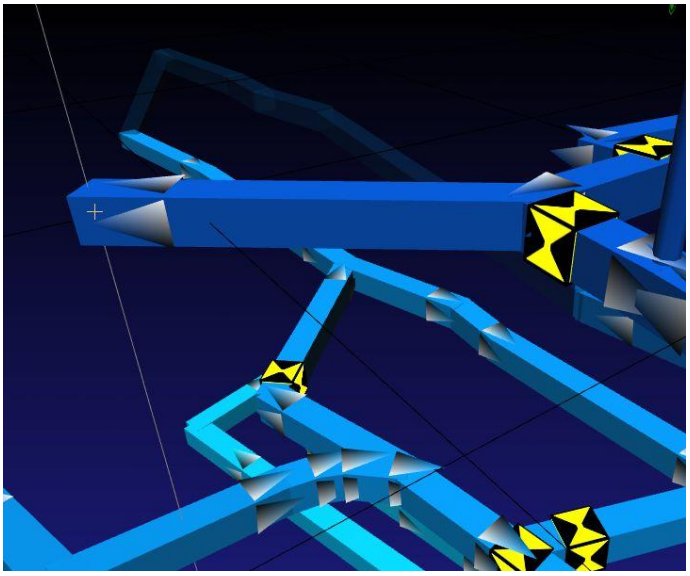


Figure 3-3 True Vertical Line showing top and bottom airways lining up

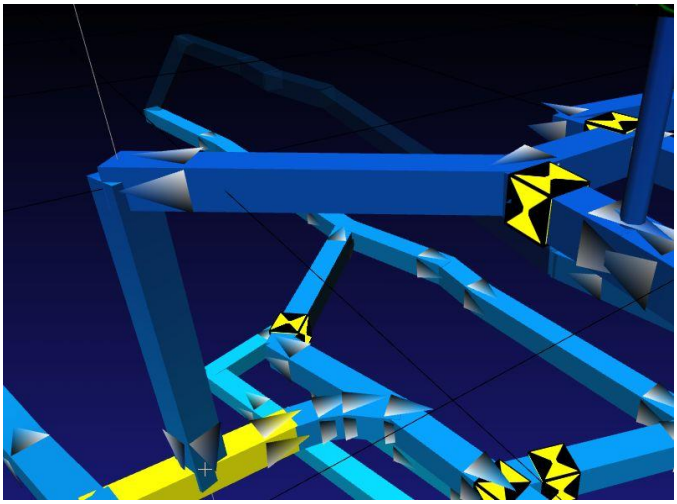


Figure 3-4 True Vertical Guide Line helps guide a shaft vertically into the airway below

3.4 Drawing in the Third Dimension

Drawing in three dimensions can be a challenge when a view is being displayed on a two dimensional monitor. Ventsim Visual™ attempts to alleviate this problem by only drawing on the horizontal plane except when the ***shift key*** or ***right mouse button*** is pressed.

3.4.1 The True Vertical Guide

3D perspective views do not necessarily show a vertical object as pointing straight up. As objects move further left and right of the point of focus, they 'lean' over away from the centre of the view. To assist the user as to which direction is truly up while creating or editing airways, a ***true vertical line*** is displayed while drawing, moving or copying. If the object being drawn aligns with the ***true vertical line***, then it is vertical. The true vertical line can also assist in locating airways directly under or over other airways at different elevations by

observing where the line 'intersects' airways above and below the current point being edited.

3.4.2 Drawing Airways

To simplify construction of airways, initially all drawing, moving and copying of airways defaults to the horizontal ***Edit Plane***, regardless of the orientation of the view screen. To assist the user further, airways being drawn or moved will automatically 'click' and join to airways under the mouse cursor, even if at different elevations or distances away.

If airways are drawn in isolation (not connected to other airways), they will use the default airway settings specified in the **Settings** form. If airways are drawn connected from another airway, they will ***inherit*** the settings from the airway from which they are drawn. Airways can be drawn from another airway end (node) or from any other point along an airway. Ventsim Visual™ will create a new node (or junction) if none already exists.

> Hint: Ventsim Visual™ can detect whether an airway being constructed crosses the paths of other airways. For example, if a long airway is drawn from one point to another, over which it crosses the paths of existing airways, Ventsim Visual™ will join this airway into the crossed airways with new nodes. This will only happen in the drawing mode. If airways are imported (from a DXF for example), crossed airway junctions will not automatically be detected).

To draw in the third dimension (up or down in elevation) where there is not an airway above or below to click to, first draw the airway to the desired horizontal (plan) location, then press the ***Shift key***. The ***Edit Plane*** will turn semi-transparent, and further movements of the mouse will occur in a ***Vertical plane*** parallel to the computer screen. The ***Edit Plane*** will follow the vertical movement, assisting in showing where the cursor is in relation to other airway elevations. In addition, the numbers in the lower left status bar will show the elevation and coordinates of the point.

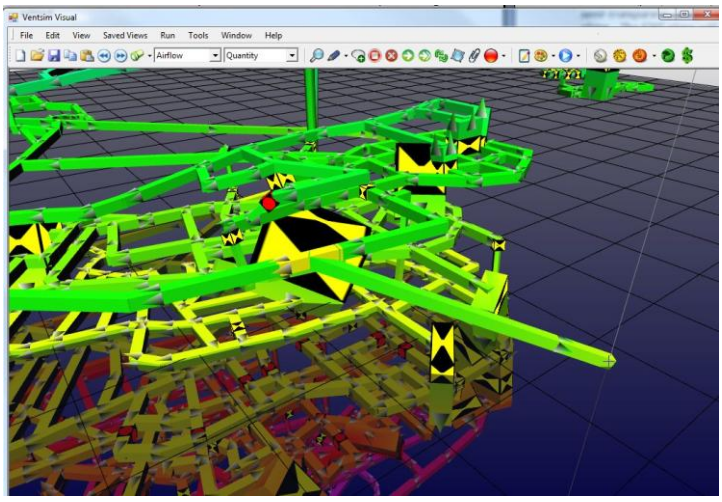


Figure 3-5 Picture showing inclined airway being drawn down to the elevation of the level below

3.4.3 Manual Coordinate Entry

Airways can be manually added, moved or copied by selected a manual coordinate entry system. To activate this system while in draw mode, click on an airway end or empty space. To activate this system every time an airway is

drawn (to allow manual adjustment or entry of airway ends) select the **pull down arrow** on the ADD button and choose the 'Coordinates' sub-options from the button.

To activate the system, when **moving** or **copying,** simply click an existing airway while in the **Move** or **Copy** mode. A coordinate window will show and the coordinates (or offsets) of the airway can be entered.

The coordinate entry allow airways ends to be adjusted manually, or by using a vector polar coordinate or a physical offset of the eastings, northings and elevation. End Coordinates are adjusted in real time as offsets or polar coordinates are adjusted. To apply the change, simply click OK when completed.

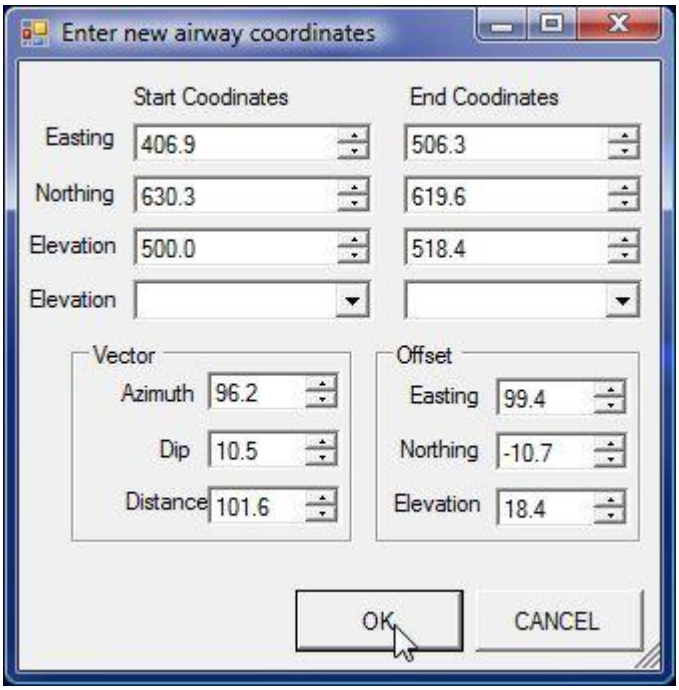


Figure 3-6 Coordinate entry system

3.4.4 Copying Airways

Airways can be copied, much in the same way as the *Move* function. An airway can be 'grabbed' with the mouse and 'dropped' in a new location, or the airway can be clicked and manually copied with new coordinates. In addition, a group of airways can be selected with the *Select* button, or by drawing a fence around the airways, and then clicking or dragging one of the selected airways.

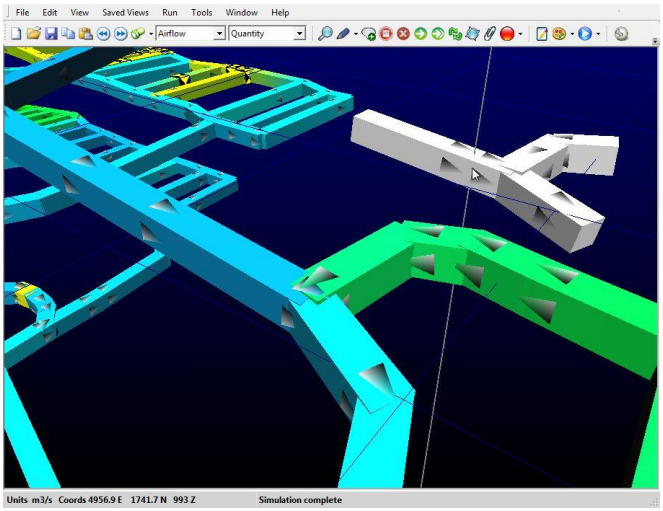

File Edit View Saved Views Run Tools Window Help
Airflow
Quantity
Units m3/s Coords 4956.9 E 1741.7 N 993 Z
Simulation complete

Figure 3-7 Example of copying a selected group of airways

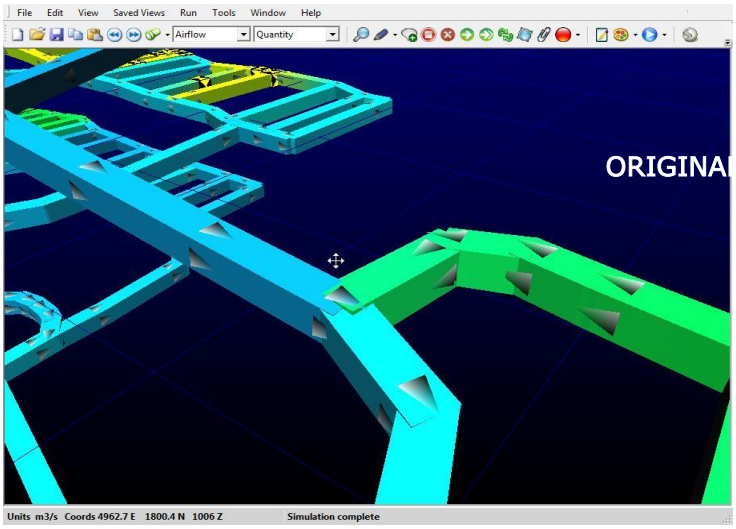
3.4.5 Moving Icons

Icon placement is not normally critical, however for fans or heat sources it can have some effect due to changes in air density and pressure along an airway. The simulation will calculate the parameters and effects of an icon as the specific point it is located in the airway. To move an icon, simply choose the *Move* mode, and select and drag the icon along the airway with the LEFT mouse button.

> Hint: Icon location can cause significant changes to fan performance on very long airways with elevation changes. For example, a fan place at the top of a 1000m deep shaft will perform very differently to a fan place at the bottom of the shaft due to different density and pressure variations at each location. Ventsim Visual Advanced will calculate the variations and simulate the fan at the location at which the icon is placed. Ensure the icon is correctly located along the airway, or use a very short airway segment (for example a short extension at the top of a shaft) to locate the icon where it is required to be simulated.

3.4.6 Moving Airways

Depending on where the airway is clicked with the mouse in *Move* mode, either end, or the entire airway may be moved. If the ends (nodes) of the airway are connected to other airways, they will be stretched to accommodate. An airway can be 'broken' away from a node by selecting it a small distance back from the node, and 'dragging' it away with the mouse. Multiple airways can be copied or moved by *Selecting* the airways (with the *Select* button, or by drawing a *Fence* around the airways while in *Move* or *Copy* mode), and then dragging the selected airways or clicking one with the mouse coordinates.



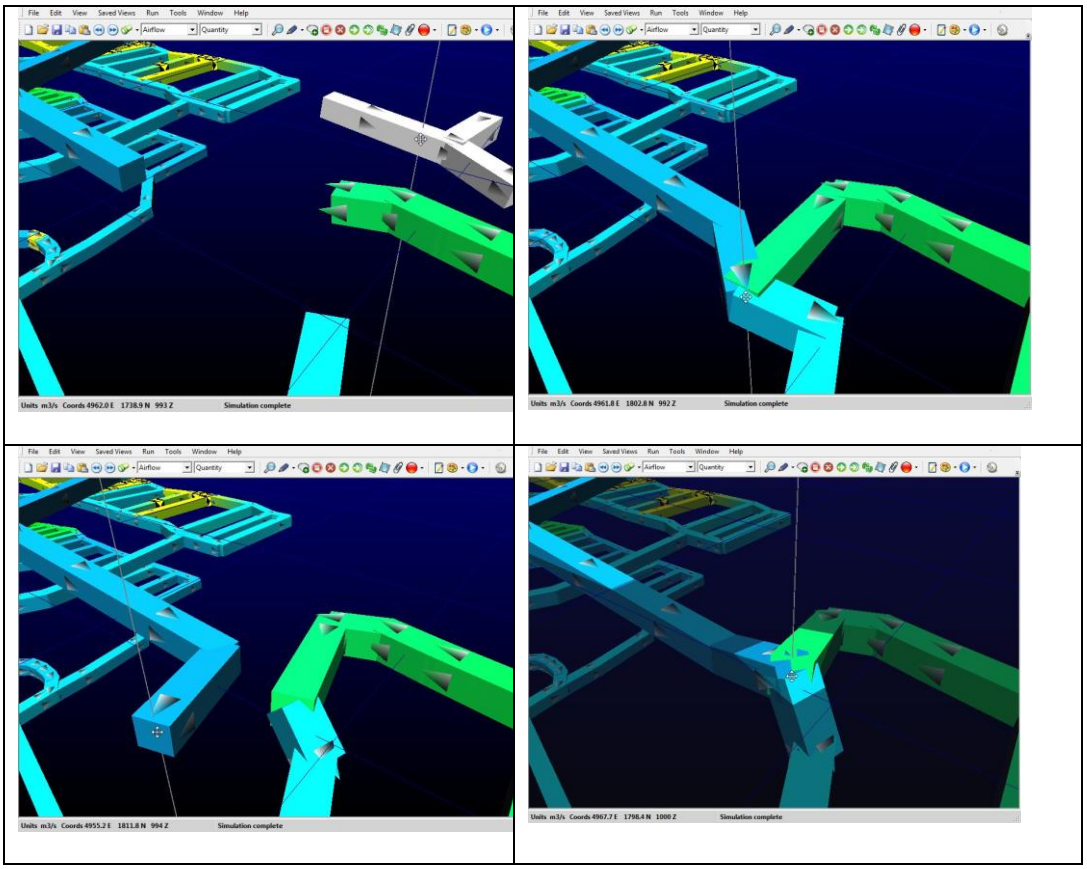
Examples of Moving Airways

Upper left : Airways are selected and then moved simultaneously

Upper right : Airway junction is moved with all attached airways

Lower left : Airway is 'broken away from node and pulled away with mouse

Lower right : Airway junction is moved vertically by pressing shift while using mouse.



Chapter 4

Chapter 4 MENU BAR

4.1 The Interface

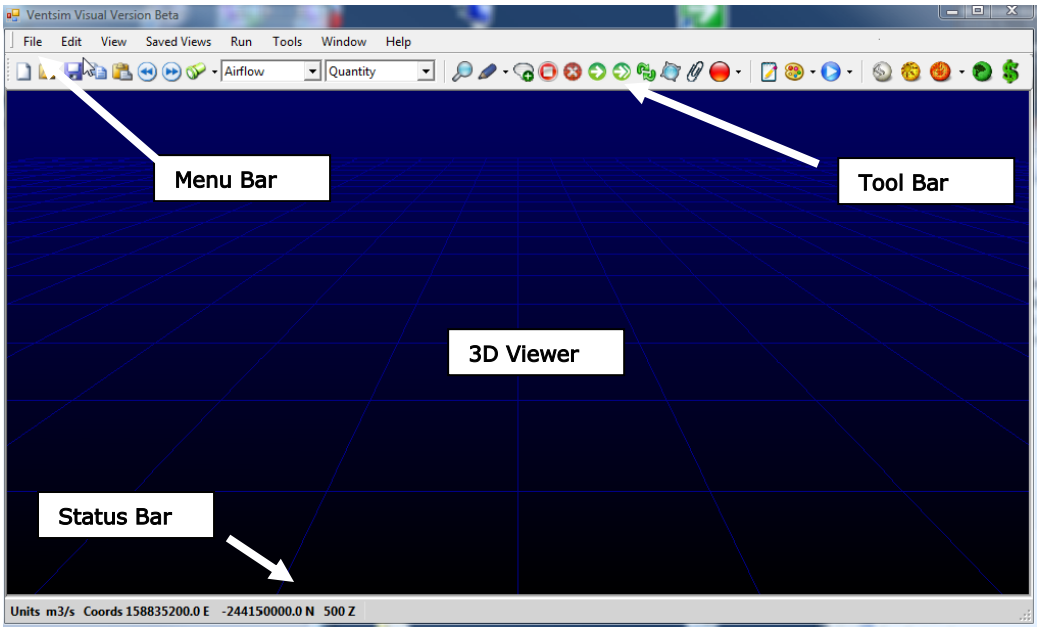


Figure 4-1 Main view window

The main Ventsim Visual™ window contains all the functions you will require to *create*, *edit*, *view* and *simulate* airway networks. Note that some of these functions may differ between ***Advanced*** and ***Standard*** versions.

Menu Bar

Tool Bar

3D Viewer

Status Bar

4.2 File Menu

4.2.1 New

Erases the network currently in memory.

An option is given to save any unsaved changes from the current network. The previously used Level, Layer and Fan Database will be retained for the new network.

4.2.2 Open

Loads a pre-saved network.

You can also open Ventsim Visual™ files by dragging file icons from your Windows folders onto the Ventsim Visual™ screen.

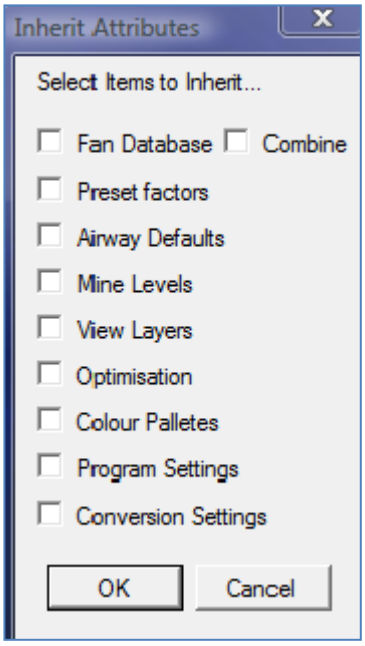
4.2.3 Merge

Joins two networks together instead of erasing the currently loaded network.

Similar to the Open command, this may be useful for joining separate networked areas of the same mine. Caution should be taken however, as duplicate branches are not immediately checked when the networks are merged (duplicate branches will be subsequently be deleted if an attempt is made to simulate the network).

4.2.4 Inherit

Adopts some of the attributes of another network.



Ventsim Visual™ files contain many different components for the network, such as fan databases, file and simulation settings, level and layer database and many other options. Instead of setting up new parameters for you network, these component can be loaded from an existing file without deleting the airway data in the current file.

Hint : Fans from other Ventsim Visual files can be used in your existing files by inheriting and 'combining' the fan databases. The simulation file fans being inherited will only be added if no existing fans exist with the same name. The 'combine' option will ensure all the current network fans will be preserved, and new fans made available for selection. The fan list can be edited from the **fan database**, or from the **Presets spreadsheet**.

Once a suitable file is selected, an option panel is displayed to allow the user to select various components they wish to inherit from the saved file. Once loaded, these components will become part of the existing file.

CAUTION – Some components such as fan databases inherited without 'combining' and mine levels may not correctly map to the existing network's fans and levels, particularly if (for example) fans within the database are in a different order. These may need to be manually corrected by checking and re-editing fan airways to ensure the correct fans have been placed.

4.2.5 Defaults

The start up settings for Ventsim Visual.

The defaults file is stored in the user's personal Windows directory. The file is loaded when Ventsim Visual™ starts and specifies the settings, behaviour and fans when the program is first loaded. Each user who logs on to the computer will have a different default file which is initially created when the program is installed.

Ventsim Visual™ files have a copy of defaults stored within the file which may have been modified after the network file was started. This will override the standard start up defaults when the file is loaded.

4.2.6 Reload Startup

Reloads the original defaults file that is first loaded when Ventsim is initiated.

This may be required if the default settings that are automatically loaded with a Ventsim simulation file are incorrect or out of date, or you wish to overwrite the current file settings.

CAUTION – This will reset all file parameters such as fan databases and graphics options. If you wish to only update selected components, use the **inherit** function to load selected components from an existing file.

4.2.7 Save Defaults

Saves the settings currently loaded in memory to the defaults file.

These will be loaded automatically next time the program is run.

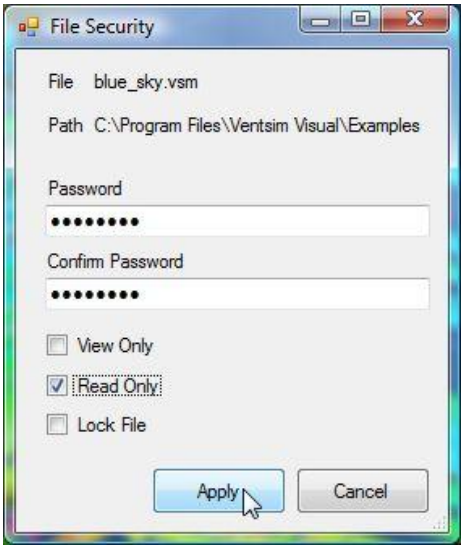
4.2.8 Restore Defaults

Restores the defaults file to the original file created when the Ventsim Visual™ program was installed.

4.2.9 Security

Sets the file security with a password to prevent unauthorised changes or access. In addition, a password protected file cannot be merged with another.

Do activate security for a file, simply select this option, enter a password and click what security option you wish to apply.



- View Only – Allows the network to be loaded and viewed, but not changed in any way or re-saved.

- Read Only – Allows the network to be loaded and modified, but not resaved or copied to a new network.

- Lock File – Prevents the file from being opened or viewed.

When a security enabled file is loaded (in Ventsim Visual version 1.2.3+), a dialog form will request a password. If the password is not entered or is incorrect, only the restricted security access option will be available.

CAUTION – Passwords are case sensitive. Ensure you can recall the password. A lost password means the file will not be able to be opened or changed in the future.

4.2.10 Save

Saves changes made to the network.

If the Ventsim title bar shows that the network is untitled, the user will be prompted to select a name before the file can be saved.

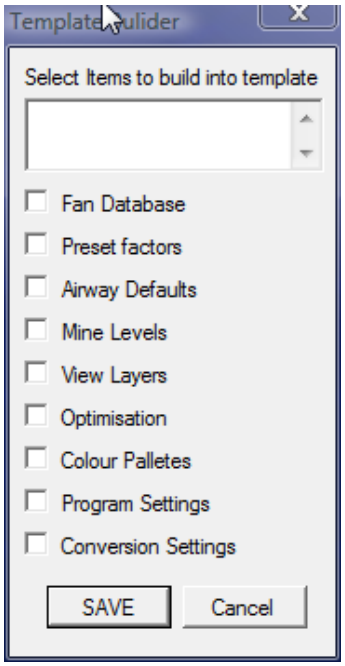
4.2.11 Save As

Saves the network, but gives the option of saving under a different name.

Ventsim can be saved in one of two formats. The default format in the VSM file which is the standard file format. This format is highly compressed and cannot be read by other programs.

Ventsim Visual™ files can also be saved as a *Text* format. This format follows the standard TAB separate values format and can be loaded by programs such as Microsoft EXCEL, WORD or ACCESS. The internal contents of the file can be viewed, modified and resaved as a *Text* file. The *Text* file can be reloaded into Ventsim Visual™ providing the basic structure and the HEADER and FOOTER tabs remain the same.

4.2.12 Save Template



Templates are collections of file setting components that you may want to either start a network with, or apply to a new network. Much like the 'inherit' function, templates can be constructed from selectable components currently loaded in Ventsim Visual™ and saved for later use. Templates will not overwrite currently loaded airway data, but will simply update the settings components belonging to the data.

Save the template in an accessible file location. A descriptor can be saved with the file to explain information about what components have been saved. To use the template in future, either double click or load the template directly in Ventsim Visual™. When loaded, the descriptor will display a window showing what components have been applied.

HINT : Templates support drag'n'drop. Simple grab the template file from a windows folder or directory and drop it on the Ventsim Visual™ screen. The current file and Ventsim Visual™ settings will be instantly updated.

CAUTION : Once again, as with Inherit and Defaults, some components saved in a template file such as fan databases and mine levels may not correctly map to the existing network file

4.2.13 Save Picture

Saves the current screen to a file location as an image file.

This file can be later loaded into documents or presentations from other software packages.

4.2.14 Import Data

Imports external data into Ventsim Visual to build network model.

4.2.15 Import Data (TXT)

Imports network data from *TXT* format (text format with fields delimited by a TAB character).

This format is widely available through most spreadsheets and can be read into word processors. The standard format for a *TXT* file can be saved from Ventsim Visual™ under the save as command. Most of the components (such as fan database and colour settings) can be excluded from a *TXT* file, leaving only the main file component if desired. The main file component must have at least coordinate data for airways to load, as well as the header name for each column.

At a minimum, a *TXT* file must have a **Header** line (the first line in a Ventsim Visual™ saved *TXT* file), and a **Completion** line (the last line in a Ventsim Visual™ saved *TXT* file)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	4	MINEDESIC	1	1	0									
2	MAIN	Entry Node	Exit Node	Branch Nai	Error Mess	pathways	X1	Y1	Z1	X2	Y2	Z2	Width	Height
3	1			Multiplate Arch		1	5510	1474	1256	5365	1558	1235	5.477226	5.477226
4	2	Tf95/Surf		Main Shaft		1	4949	1950	1257	4950	1950	1233	5.6	5.6
5	3	TVR/Surf		Temp VR		1	5396	1791	1256	5396	1791	1200	3	3
6	4	Surf/Rb82	60/Rb82	Rb82		1	4827	1716	1257	4827	1716	1194	3.5	3.5
7	5					1	5027	1780	1256	5027	1780	1179	4.1	4.1
8	6					1	5018	1798	1256	5018	1798	1176	4.1	4.1
9	7			SZ Decline		1	5365	1558	1235	5160	1677	1206	6.3	6
10	8			Fowler Shaft		1	4950	1950	1233	4950	1950	929	5.6	5.6
11	9					1	5160	1677	1206	5153	1679	1205	6.3	6
12	10			60mLv Access		1	5153	1679	1205	5012	1659	1187	6.3	6
13	11		Sa50/Surf	Sa50		1	4500	1800	1202	4500	1800	1265	5.6	5.6
14	12			Temp VR		1	5396	1791	1200	5396	1791	1121	3.8	3.8
15	13					1	4760	1571	1200	4825	1537	1192	4.5	4.5
16	14					1	4752	1624	1195	4768	1624	1194	5	5.2
17	15					1	4742	1605	1195	4760	1571	1200	4.5	4.5
18	16					1	4752	1604	1195	4752	1624	1195	5	5.2
19	17					1	4752	1604	1195	4742	1605	1195	4.5	4.5
20	18					1	4837	1720	1194	4836	1716	1194	5	5.2
21	19					1	4829	1718	1194	4837	1720	1194	2	2
22	20					1	4836	1716	1194	4832	1700	1193	5	5.2
23	21	60/Rb82				1	4827	1716	1194	4829	1718	1194	1	1
24	22	60/Rb82		Rb82		1	4827	1716	1194	4827	1716	1162	3.5	3.5
25	23			Qb80#1		1	4768	1624	1194	4770	1622	1256	2.2	2.2

Figure 4-2 An example of a Ventsim Visual™ Text File Loaded into Microsoft Excel

4.2.16 Import Data (DXF)

Imports ***DXF*** formatted data (supported by most CAD and Mine Planning packages).

Imports DXF graphics items can serve two function. Importing line string graphics can allow Ventsim Visual to directly create new airways, using the line strings as centre lines for the development. The centrelines can be converted to airways during the import function, or later on by selectively clicking or fencing the centrelines with the Add > Convert function. Further utilities under the tools menu allows users to quickly turn the new airways into viable networks.

> HINT : Loading centrelines as a reference graphic without converting to airways can allow the user to check where extensions or changes to a mine network may be, particular if some of the centrelines may overlap existing airways. The reference lines will extend from existing ventilation airways showing where extensions to the mine ventilation network may be required. The referenced centreline can then be selectively clicked or fenced to convert to airways using the **Add >Convert** function.

A second option allows importing DXF as 'references', which places the graphics within the network, but does not affect or interact with the network airways. Examples may include mine surface terrain, orebodies, actual development solids etc. This option allows the reference graphics to be used as a guide to building new airways, or simply enhances the display with more information about the mine environment. Any solids that are present in the DXF will automatically be imported as a 'reference' graphic, as Ventsim Visual cannot build new airways from graphical solids (only centrelines)

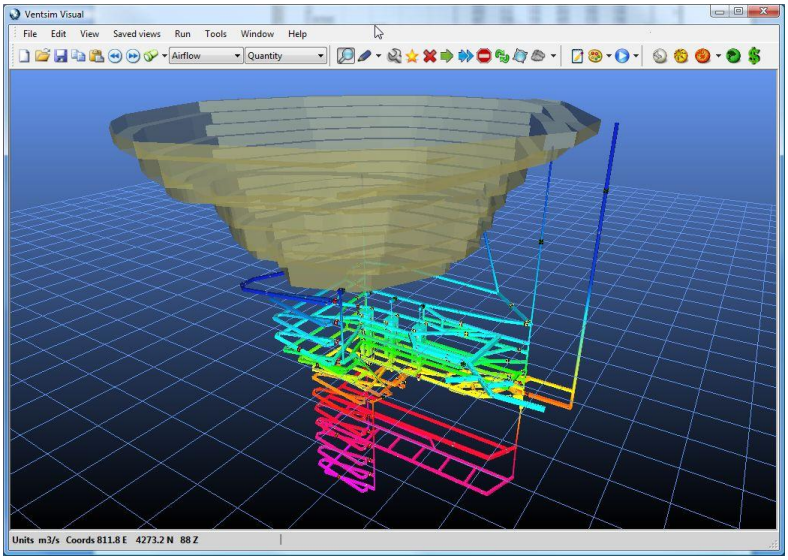
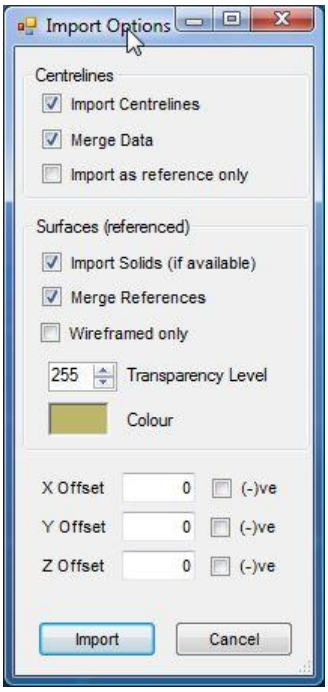


Figure 4-3 Ventilation network showing 3D DXF pit within network

DXF files can be merged with an existing network (for example a mine addition), and new airways built with DXF centre lines can be set with default attributes (airway sizes etc) before importing. Attributes can easily be changed later within the program.

> HINT : Both TXT and DXF files support drag'n'drop. Simple grab the file from a windows folder or directory and drop it on the Ventsim Visual™ screen. More than one DXF file can be imported at a time by using the SHIFT or CTRL key to select and load the files.

DXF files can be merged with an existing network (for example a mine addition), and new airways built with DXF centre lines can be set with default attributes attributes (airway sizes etc) before importing. Attributes can easily be later changed within the program.



Import Options Ventsim Visual will search a DXF file for both line strings and solids. The import options indicate what action to take if these items are found.

Centrelines
Centrelines (lines or polylines) can be either converted to ventilation airways, which will carry airflow within a ventilation network, or simply as a reference graphical line string, which will not affect a mine ventilation network, but which can be used to help guide and place manually constructed airways.

Import Centrelines Disabling this function will tell the program to ignore any line strings found.

Merge Data Adds the new imported data to the current network

Import as reference only Tells the program NOT to build airways out of centrelines, but simply import as a graphical reference. A centreline can be converted later to an

airway using the **Add > Convert** function.

Surfaces (referenced)
Surfaces or 3D solids cannot be directly converted into airways, however than can provide a useful reference to manually developing Ventsim Airways. In addition, they can provide an important visual aid to viewing ventilation networks within an actual mine environment.

Import Solids Disabling this function tells the program to ignore and not load any solid graphical data found in the DXF file.

Merge References Adds the imported data to any existing referenced solid graphical information already within the network

Wireframed Only Adds the imported data as a wireframe line solids, instead of a polygon solid.

4.2.17 Manage References

Provides a utility to separately manage any imported graphics reference. Each imported object can be separately coloured, made transparent or hidden from the main view through the form options.

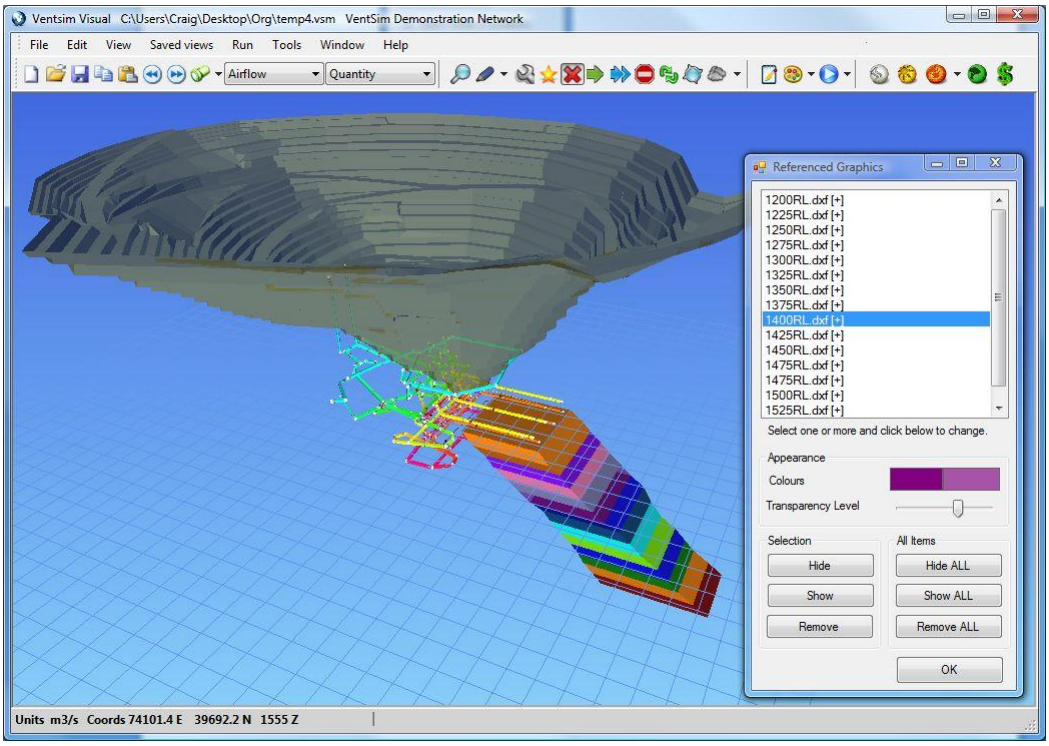


Figure 4-4 Reference Graphics Manager

Select one or more graphics objects from the list with the mouse (hold the shift key down to select multiple items). A [+] against the name indicates it is currently being shown. A [-] indicates it is currently hidden.

Colour Changes the colour of the items. The second colour shows the transparency effect on the colour.

Transparency Changes the transparency of the item.

Hide Hides the object from the screen view

Show Shows the object in the screen view

Remove Removes the object from the file

4.2.18 Title Note

Allows the user to specify a unique file comment which appears in the top title bar.

This comment can help identify the date, name and purpose of the network.

4.2.19 File Memo

Allows users to write an extensive descriptor regarding the function or description of the current network.

This is saved with the file for future reference.

4.2.20 Page Setup / Print / Print Preview

Prints a graphic picture of the network in the View Window to an installed printer.

Only printers with Windows supported graphics capabilities will be capable of printing the network. As Ventsim Visual™ uses a perspective view, no particular scale is applied to the image. The image is sized to the maximum size of the page and orientation. To reduce colour output, the Ventsim screen colours can be changed under the Tools > Settings > Colours menu.

4.2.21 Previous File Listing

Quickly loads files recently loaded or saved.

4.2.22 Load Demonstration

Loads a generic network of a typical mine.

This is for demonstration purposes only.

4.2.23 License Manager

Opens the License Manager form.

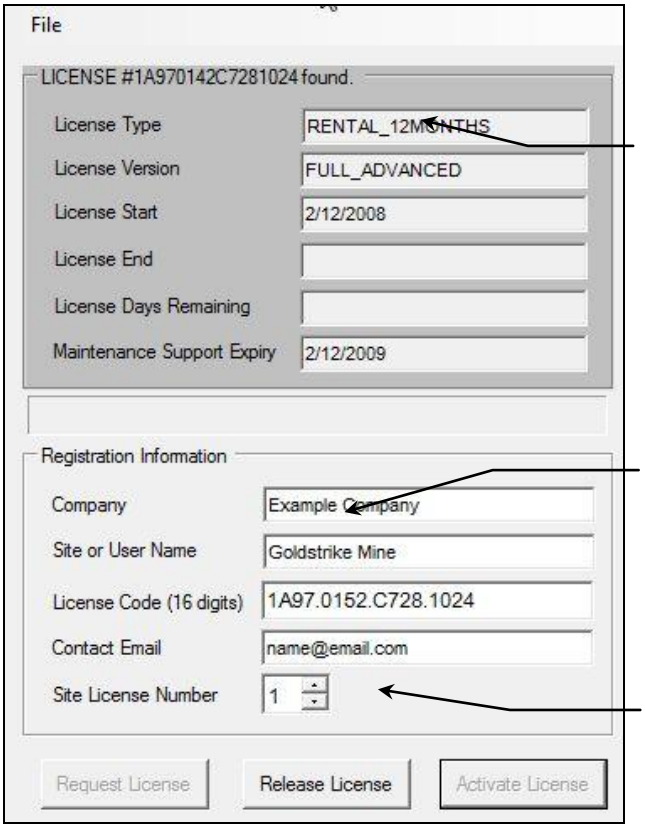


Figure 4-5 Automatic License Activation and Release

Licenses

Ventsim Visual™ licenses are floating licenses which can only be used on one computer at a time. They can be *activated* for use on one computer and then if required *released* and used on another computer (within the terms of the license agreement). License certificates are stored on the Ventsim server and prevent simultaneous installation of the same license on more than one computer.

As part of the digital licensing agreement, the license collects the computer name and user name of the computer that Ventsim Visual™ is currently activated on. This system protects against unauthorised use of the Ventsim Visual™ license and informs the user who has currently activated the software license.

Releasing a License

Once a license is activated on a computer, it cannot be moved to another computer unless it is first ***released*** from the activated computer. If another computer tries to activate the same license simultaneously, this will be prevented and a warning will display the currently licensed computer and the login user name of the person who has installed it.

An internet connection is required to activate and release license certificates from a computer. If an internet connection is not available or an internet connection is not authorised by your firewall or company administrator, try to arrange a link to the http:\\ventsim.com website. If this cannot be done, a manual license transfer can be performed via email located under the file menu.

Manual License Activation

In the event an internet connection cannot be made available to activate the software, and manual licensing system can be used. The manual licensing system still requires transfer of a file via email or FTP.

The license request file can be manually saved and emailed to license@ventsim.com. Once authorised (which may take up to 48 hours), an authorised license file will be emailed back and can be installed on the computer via the 'LOAD' option under the FILE menu.

4.2.24 Exit

This command closes Ventsim. Ventsim will prompt if your network file, fan database or defaults have not been saved since last modified.

4.3 Edit Menu

4.3.1 Undo

Reverses the previous action

Undo is a fully functional undo facility that will undo a number of previous changes made to a network (up to the buffer size of the undo function). Note that while it will not directly undo a simulation, by pressing UNDO until your previously network is in place and then re-simulating, this will produce the same results.

4.3.2 Redo

Redo will reverse the result of the undo function.

4.3.3 Copy and Paste Airways

Copy airways from one Ventsim Visual™ program to another.

Copy and Paste Airways creates an *exact* replica of selected existing airways in a network and pastes them into the same location into the existing or new network. The function is primarily designed to copying and paste airways between network files. This may be required to update airways from a network that has been modified into another network.

To use this function, ideally have two copies of Ventsim Visual™ open with different network files. Select the *Copy Airways* menu item, and click on, or fence the airways you wish to copy.

To paste the airways, move to the new network (or load it up) and select the *Paste Airways* menu item. The copied airways will be pasted into the new network.

If airways become duplicated in the process, Ventsim Visual™ will delete one of the duplicate copies.

4.3.4 Clone and Apply Attributes

Clones selected attributes from one airway and applies the attributes to another.

Attributes are physical airway parameters such as size, friction factors and shock losses, as well as identifying attributes such as layers. You can decide which attributes to apply to an existing airway by selecting the **Clone Options** function from the menu or Select Manager Form from the toolbar.

To clone attributes, select the *Clone Attribute* menu item, and click on an existing airway. The airway properties will be copied to memory and the program will automatically enter the *Apply Attribute* mode.

To apply attributes, make sure you are in the *Apply Attribute* mode if it has not already been selected and either click on an existing airway, OR fence a selection of airways to apply the attributes to that group. Cloned Attributes can be applied at anytime (even after other editing has been done) and will apply the most recently cloned values.

4.3.5 Lock Target

Locks on to the closest airway when add, moving or copying new airways. Deselecting this option will allow airways and nodes to be finely moved without locking on to a nearby node or airway, or to travel through each other without connecting.

Hint : The lock target can be deselected when arranging airways which are closer together. The lock function when selected will normally lock on to the closest available airway, ensuring a positive join between the airway.

Warning. If the lock target function is turned off, airways may not join into each other precisely (even if they appear close or overlap), resulting in no exit or entry errors. The 'lock target' function should always be selected when you intend to join into other airways or nodes. You can check whether airways truly join into each other by turn on the NODE display.

4.3.6 Lock Transparency

Allows transparent (non active) airways to be also locked, selected or edited. Transparent airways are normally treated as invisible by the program and by default cannot be selected or changed. Enabling this function will allow the airways to be selected or edited the same as any other airway.

4.3.7 Lock Vertical

Forces new airways, or moved or copied airways to be drawn exactly vertically when the vertical movement function is chosen (with the SHIFT key or the RIGHT MOUSE button) while drawing. When this function is not selected, airways can be moved both vertically and parallel to the plane of the viewing screen while being drawn.

Hint: Airway drawn or moved with the Lock Vertical function activated can still be angled. Simply release the SHIFT key or RIGHT mouse button while drawing and moving when you are at the desired elevation and the airway end can continue to be moved horizontally at the new elevation.

4.3.8 Lock On References

Locks the mouse onto a referenced graphic surface or wireframe IF AN AIRWAY IS NOT PRESENT. Ventsim Visual will preferentially search for airways when clicking to new locations. If no airway is found, when this option is enabled the program will search for a reference graphic to lock on to.

Hint: This function is very useful for tracing or moving airways on to imported referenced graphic locations. By using the referenced graphics as a guide, airways can be accurately placed within a network. To force the program to use the referenced graphics only, and not lock on to other airways, turn the Lock Target options OFF.

4.3.9 Check Intercept

Checks whether new airways intercept existing airways, and inserts a node if they do. The function works by searching surrounding airways for intersections or crossing paths that are close. Turn this function OFF if you require an airway to cross another without joining (for example an overcast airway) or airways are required to be drawn very close together without being joined.

Hint: When drawing Vent Duct within or close to an airway, ensure this function is turned OFF. The Vent Duct airway may inadvertently join into the adjacent airway, creating shortcuts or duplicate airways.

4.3.10 New Airways

Control which attributes are applied to new airways.

Use Inherited New airways drawn from existing airways will inherit the settings from the airways they are attached to (such as size, shape, friction factors etc). Airways which do not originate from another airway will use the default setting values.

Use Defaults To force the program to use the Default Values (from the **Settings** Menu), choose Default. All new airways drawn (regardless of whether they connect from existing airways) will use the default settings.

Use Cloned Forces the program to use the **Cloned Settings** from a previously cloned airway. For example if a shaft is to be drawn from a horizontal airway, cloning a similar shaft and then drawing the new airway with this function set, will result in a new shaft with the same size, parameters and layer settings as the cloned shaft.

4.3.11 Find / Find Next / Find ALL

Automatically locates specific airways and moves the screen to selected parts of a network.

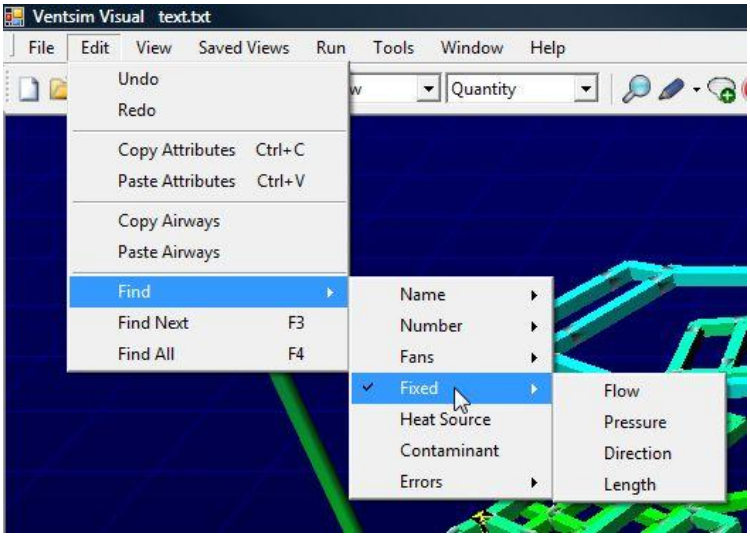


Figure 4-6 Find Airway Data

Selecting one of the options will find and highlight the airway searched for. The option may be repeated for further branches by pressing the *Find Next* menu function, the *Find* tool bar button or by pressing *<F3>* on the keyboard. To find *All* instances of an airway (for example to find all airways with the name 'shaft' in the airway name, or to find all fans, click on an initial find type and then click on *Find All*. All items with these parameters will ***Highlight and Flash***.

> HINT – Pressing <F3> will rapidly allow you to search through a network, by repeatedly jumping to the next item. To view more detail about the items being jumped to, LEAVE THE EDIT BOX open. The EDIT BOX will instantly update with detail about every airway that is jumped to.

4.3.12 Highlight or Select All

Highlights or select all airways matching the previous find criteria. For example, if FIND was used to locate an airway with the name "M52 Decline", Select All would select ALL airways with this name in the airway name field. The selected airway could then be edited or manipulated as a group.

4.4 View Menu

4.4.1 Fit All

Fits all the display data into the view window.

CAUTION : If display data is from two regions a long way apart (for example data may have been imported into Ventsim Visual™ from a different coordinate system). The Fit All may not be able to accommodate the range of data attempted to be shown, or the camera may be too far away to view the data effectively. Ensure all data is in the same coordinate region before it is loaded or merged.

4.4.2 Show All

Resets all hidden levels, layers and airway data and displays the entire network. Occasionally a network may have hidden or semi-transparent airways set from a previous action. Show all will quickly bring the entire network back to full view.

4.4.3 Show All

Shows all elevations and layers in the mine.

Levels are definitions or ranges of elevations on which airways data may be separately located and viewed. Elevation ranges can be given names (such as '1140 Level') in the ***Level Database***. *Show All* will force Ventsim Visual™ to show all elevations of airway data in your network, even if they are outside of the ranges specified in the ***Level Database***.

Show Levels / Layers : Similar to Show All, the respective functions will limit the showing of all display to the either all levels or all layers.

To select a single level range, use the *Right Mouse* button and choose the context menu item *Select Level* to narrow your range to one or more elevation levels. Click on one or more airways or *fence select* a group of airways, and then *Right Mouse* click to confirm selection. All airways outside the elevation range will be hidden or made transparent. The level of transparency can be adjusted from the ***Colour Palette Manager.***

HINT: Airways outside of the normal range of the LEVEL (elevation) database will be displayed as invisible or transparent. The LEVEL database should have a least one level which encompasses all elevations of airway data in your model.

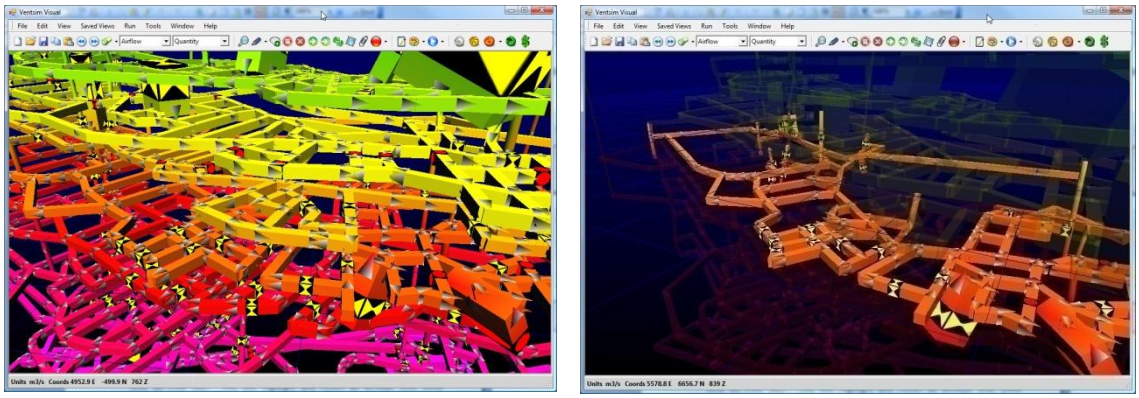


Figure 4-7 Examples of using 'Select All' and 'Select Level'

4.4.4 Quick View

Quick Views are temporary saved views which can quickly be saved and recalled sequentially outside of the normal Saved View system. Quick views are not added to the Save View menu selection. The views can be quickly recalled at any time using the arrow keys. The function primarily assists with navigation of large networks, where different areas can be quickly returned to for viewing simulation results.

Save Quick View
Creates a temporary view position for a network. The view is added sequentially to previous stored Quick Views. The sequence of stored quick view can be recalled or returned to using the LEFT and RIGHT arrow keys.

Clear Current
Clears and removed the currently recalled quick view. The view is removed from the sequence of other stored Quick Views, and can no longer be recalled.

Clear ALL
Clears all Quick Views from memory.

Previous Quick View
Recall the previous Quick View from the sequence of saved Quick Views.

Next Quick View
Recalls the next Quick View in the sequence of saved Quick Views.

4.4.5 Static View

Creates a picture copy of the current window in a new form window. Static Views are primarily for referencing areas before and after simulation. It may be useful in showing a sequence of changing ventilation simulation results by storing previous results for comparison with new results.

The form window defaults to 25% of the size of the normal view window, but can be resized or maximised at anytime to show full detail. The static view forms can be renamed for reference or saved to a picture JPG file for future use in other software.
Static views are simply picture copies of the original network and remain the same regardless what happens to a network after the static view is created. They cannot be edited, moved or rotated. The number of static views created is only limited by the memory capacity of the computer.

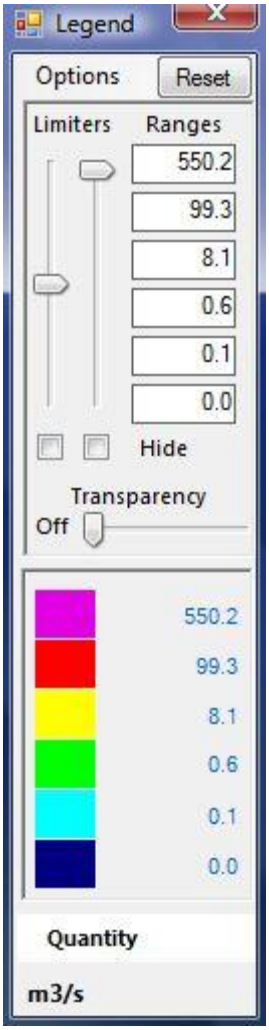
HINT : Both the EDIT box and the FAN DATABASE form can also be reproduced as a STATIC view. This is useful to provide a quick comparison between airways or network results before and after simulation changes. To use this function, simply RIGHT click the EDIT box or FAN form, and select Static View

4.4.6 Set Edit Centre

Sets the edit grid and point of focus to a specified coordinate or elevation.

New airways will be drawn on the specified elevation

4.4.7 Colour Manager



The COLOUR MANAGER is a powerful tool which controls the colour and transparency of all items on the screen.

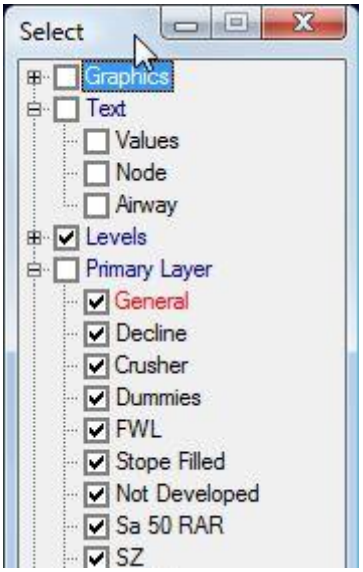
Up to 50 types of different ventilation data can be automatically coloured and displayed in different ranges. The data type can be chosen by clicking the box at the base of the form, and selecting the data you wish to display. The colour display can work independently of the *Text* units displayed on the screen.

For example, if the pressure differences relatively to surface need to be viewed in different colours, select ***'Pressure – Relative P'***. The colour range according to pressure will be automatically spread across airways, however can be manually adjusted by typing different range values in the top fields. Another option may be to view the ***Power – Ventilation Cost*** of airways for a year. The function makes analysing networks and viewing potential problems or solutions very quick

The sliders at the top left of the form can narrow the colour spectrum and range shown. By clicking the *Check* boxes below each slider, airways outside of this range can be made semi-transparent or even invisible by using the horizontal slider.

See the Colour Manager for further information.

4.4.8 Display Manager



Displays the DISPLAY MANAGER

The display manager allows fine details control over what is displayed on screen, such as graphics items, layers, levels and other options.

The Display Manager allows control over graphics options, elevation levels, layers, saved views and copy and paste options. It also permits level and layer names to be changed by pressing the RIGHT mouse button.

See Display Manager for further details.

4.4.9 Animate Flows

Activates the flow animation system to animate flow direction arrows.

This function is for display purposes only, and does not play a part in simulation or control. Flows arrows are animated at either scale (real time) speeds, or by a factor of x5 or x10. Flow animation may be left on all the time, but will slightly hinder system performance, particularly on very large networks.

4.4.10 Text Data

Controls how much text information is displayed on the screen.

Display ALL Displays text information for data values, node names, airway names and error messages.

Hide ALL Hides all text information.

Data, Airways, Nodes Text data, airway names or node names can be individually turned on or off by selecting them from the view menu or by selecting or deselecting from the right mouse button popup **menu.**

4.4.11 Limit Data

Provides options for limiting the amount of data displayed in a network. For complex networks, displaying data for every single airway segment this can lead to a cluttered display, and is often unnecessary, particularly if the data shown is largely the same (for example airflows). For other items however (such a heat flows) this large amount of text data can still be useful.

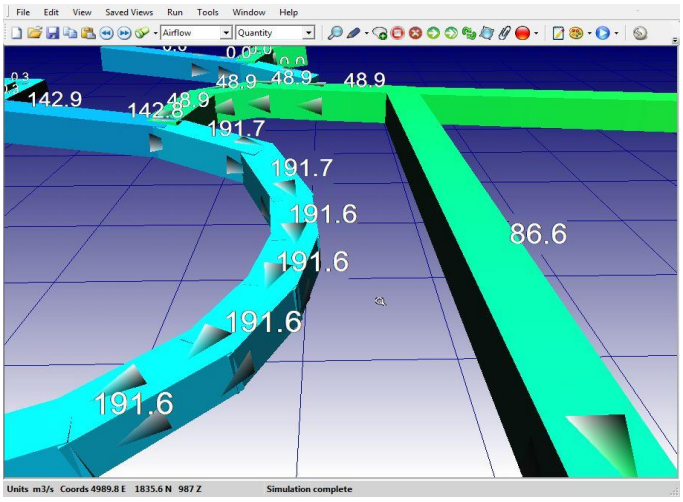


Figure 4-8 Example of unlimited text display

Hint : For data which may vary from one end of an airway to another (such as temperature), Ventsim Visual™ will always show the ENTRY data on the airway unless otherwise specified.

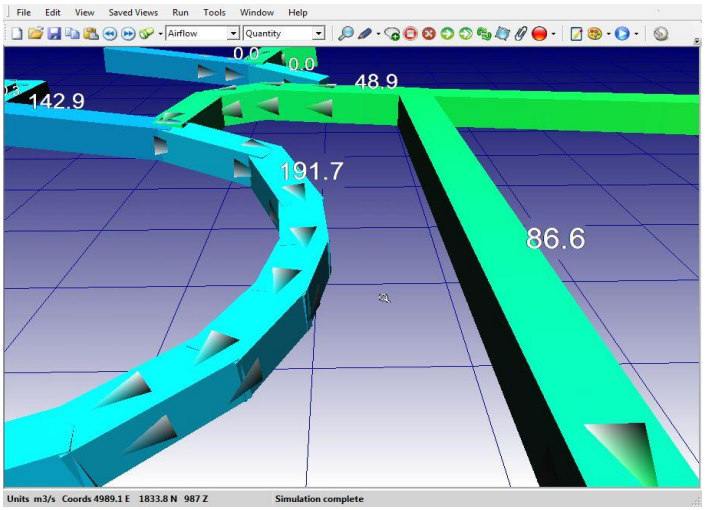


Figure 4-9 Example of Limited Text Display

Show Limited Only displays text, nodes and/or arrows on airways which specifically have 'Always Show Data' option set in the EDIT box. For example a loop in a decline consisting of 10 airway segments, will normally show data for every segment. To only show one text data for all the segments, ensure only one airway is set to 'Always Show Data", and the activated the LIMITED > text display. To force an airway segment to show data, use the EDIT box and click 'Always Show Data'.

Show Unlimited Shows all data for the airways, regardless of whether the 'Always Show Data' option is set in the Edit box.

4.4.12 Transparency

By default, all data which is non active (for example levels or layers which are turned off, data which is outside of the Colour Manager display, or zero flows if set) are shown as a transparency, with the transparency amount set in the Colour Manager. To specifically hide some items (for example layers which you do not want to see), but still show transparencies for other items (for example Zero Flows or Coloured Data), you will need to individually set which transparencies are to be shown.

Data : coloured data which is outside of the selection range in the Colour Manager, and is selected to be hidden can be made transparent, or removed from the display.

Levels : level elevations outside of the selected ranges can be made transparent or hidden

Layers (primary and secondary) layers that are not selected can be made transparent or hidden.

Zero Flows : Airways carrying no flow can be made transparent or hidden.

4.4.13 Hide Zero Flow

Hides airways with no flow. This function is useful for hiding disused or unventilated parts of a mine so they do not clutter the display. Airways with no flow (or airflow below the level set as zero flow value in the Settings menu) will be shown as transparent or hidden, depending on the transparency settings described above, and the transparency amount set in the Colour Manager.

4.5 Saved View Menu

4.5.1 Save View

Saves the current view and stores the save name in menu for future recall. Save view will save all attributes in a view including RL levels, layers and display options. Saved views can be pulled back into any current window by selecting the saved name from the pull down view list.

4.5.2 Delete View

Deletes the saved view stored in the CURRENT pull down menu list (and hence removes this name from the list).

4.5.3 Saved Views

Four view orientations are set as defaults

- PLAN
- EW SECTION
- NS SECTION
- ISO

These standard views will display the network at various orientations (although the network can still be orientated to the same orientations by using the RIGHT mouse button. These views cannot be deleted or changed

Caution: The Perspective view will distort some aspect of the views. For example, the plan view will show the airways at the EDIT grid level to plan, but airways above and below this elevation will appear larger and smaller respectively.

Any further saved views will be placed below these items. Saved views save the position, orientation, colour scheme and data types and attributes of the screen at the time at which they were saved.

Hint: Saved views are not only useful for recalling the location and orientation of a network. Because they recall selected levels, layers, data types and colours, they can be a quick way to establish a template to edit and view different data aspects of your network. For example, you may have an AIRFLOW view, custom set to highlight a certain range of airflows in different colours, while a 'HEAT' view may be saved to highlight a range of temperatures.

4.6 Run Menu

The RUN menu allows menu access to the main simulation functions of Ventsim Visual.

Standard Functions

- Airflows
- Contaminants

Ventsim Visual™ Advanced Functions

- Thermodynamic
- Diesel Particulates
- Recirculation
- Financial

4.6.1 Thermo-dynamics [ADVANCED]

Undertakes a thermodynamic simulation process, which derives initial airflow (and mass flows) from an airflow simulation. Thermodynamic simulation is complex and endeavours to simulate numerous parameters encountered in a mining environment. The simulation process follows well documented methods found in books such as *Subsurface Ventilation and Environmental Engineering by Malcolm J. McPherson*. Heat parameters that Ventsim Visual™ Advanced considers includes

- Heat and moisture derived from rock strata and ground water.
- Thermal properties of different rock types.
- Heat from point sources (such as electric motors), linear sources (such as conveyors), diesel engines and oxidisation of ores.
- Heat from auto-compression of air.
- Refrigeration and spot cooling of air.
- Changing densities throughout the mine, due to depth and temperature effects, as well as pressure from ventilation flows.
- Natural ventilation changes from changing densities.
- Artificial moisture from sources such as dust suppression sprays, spray chambers.

- Condensation from over saturated air

To accurately model a mine, all of these factors must be considered and entered into a network. If data for a parameter is not entered, Ventsim Visual™ will assume a default value specified in the ***Settings***, and in most cases will simulate a result anyway. The accuracy of this result will largely depend on the accuracy of the entered data, and the default values used. More information regarding Thermodynamic simulation can be found later in the manual.

4.6.2 Diesel particulates [ADVANCED]

Simulates the spread of diesel particulates throughout a mine network, derived from diesel heat sources placed throughout the network. The simulation process assumes a steady state emission of diesel particulate sources and a uniform mixing process throughout the network and its junctions. Note that this may not always be the case in a real mine, where incomplete mixing and dynamic changing of exhaust emissions through the day can change concentrations of diesel particulates at different times, however it provides a useful baseline to examine the effects of changing ventilation circuits and flow in a mine.

For more information see Diesel Particulate Simulation

4.6.3 Recirculation [ADVANCED]

Examines a network for paths which may recirculate airflow in a mine.

The definition of recirculation is the passage of airflow or a portion of airflow through the same point in a mine more than once. Ventsim Visual™ uses a custom algorithm to track the paths of every airflow throughout a mine, and report where airflow may recirculate. To prevent trivial reporting of recirculating air (such as minor leakage of air through a high resistance stopping) a default tolerance of 1m3/s or 0.1% recirculation is used. These limits can be changed in the Settings form. Recirculating airflows are shown as 'flashing airways'

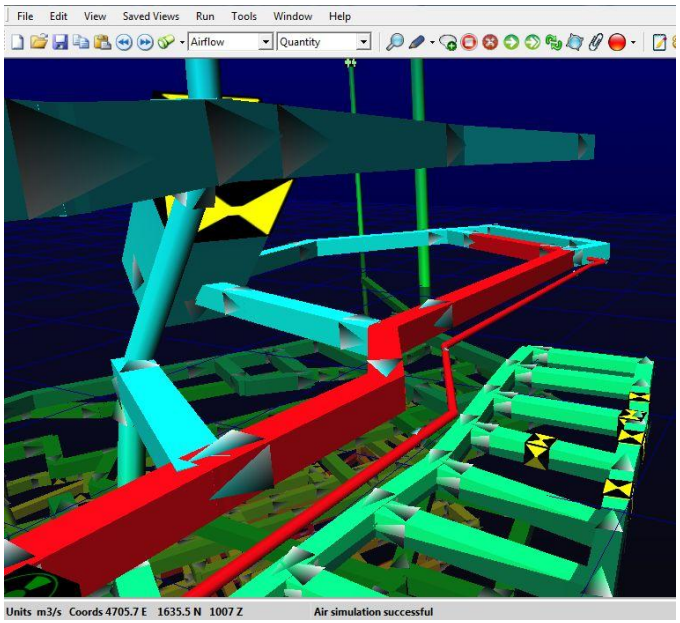

File Edit View Saved Views Run Tools Window Help
Airflow
Quantity
Units m3/s Coords 4705.7 E 1635.5 N 1007 Z
Air simulation successful

Figure 4-10 Example showing a ventilation fan recirculating air

4.6.4 Financial Simulation [ADVANCED]

Assists in choosing the most economical airway sizes for the ventilation required.

This function can help optimise the size of shafts or horizontal development airways, to maximise cost savings in ventilation, while minimising mining costs. This function can only be used on a single airway (such as a shaft), or groups of airways with the same size (for example a decline system)

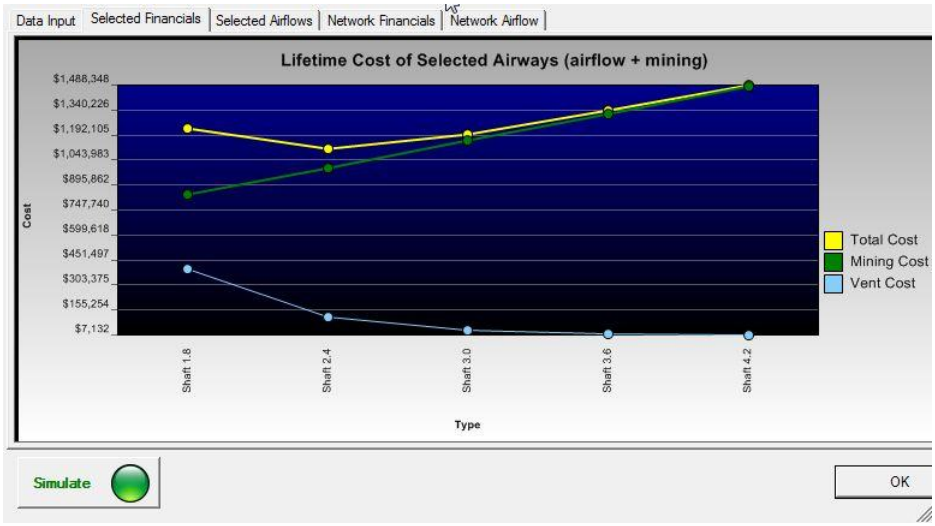
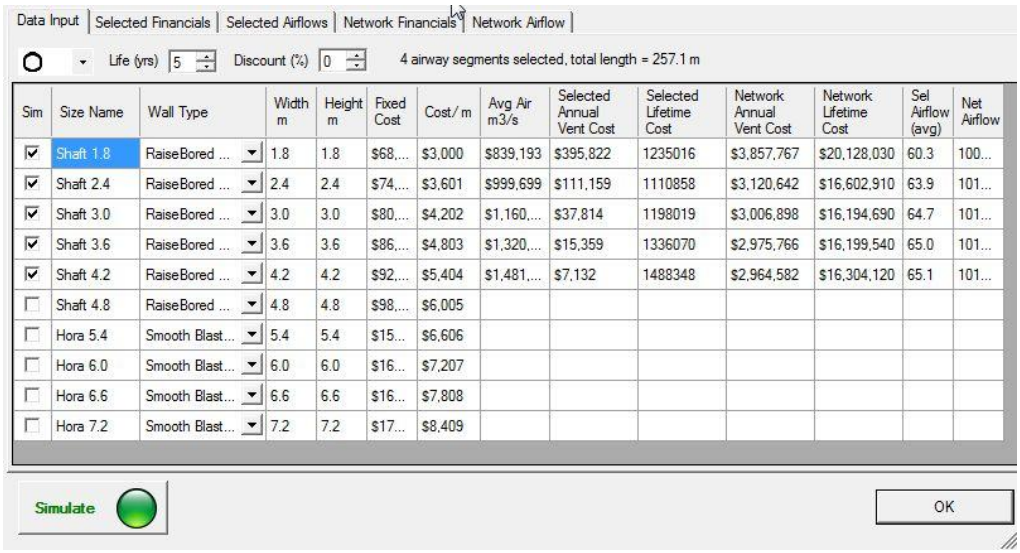


Figure 4-11 : Financial Simulator Output showing life of mine airway costs

Increasing airway size is the easiest way to reduce friction pressure losses and decrease ventilation costs in a mine. Increasing airway size however creates additional mining costs, and this is further exacerbated by the 'time value of money' which dictates that a dollar saved in mining costs now is worth more than a dollar saved in ventilation costs in the future. Another factor to consider is how long the airway is required to carry air, which affects how much ventilation cost can be saved in the future.

The financial simulator takes all this into account, and simulates up to 10 different airways sizes for an airway or group of airways, reporting the effect on mining cost and ventilation costs as an NPV (net present value) adjusted overall cost.



Sim	Size Name	Wall Type	Width m	Height m	Fixed Cost	Cost/ m	Avg Air m3/s	Selected Annual Vent Cost	Selected Lifetime Cost	Network Annual Vent Cost	Network Lifetime Cost	Sel Airflow (avg)	Net Airflow
☑	Shaft 1.8	RaiseBored ...	1.8	1.8	$68,...	$3,000	$839,193	$395,822	1235016	$3,857,767	$20,128,030	60.3	100...
☑	Shaft 2.4	RaiseBored ...	2.4	2.4	$74,...	$3,601	$999,699	$111,159	1110858	$3,120,642	$16,602,910	63.9	101...
☑	Shaft 3.0	RaiseBored ...	3.0	3.0	$80,...	$4,202	$1,160,...	$37,814	1198019	$3,006,898	$16,194,690	64.7	101...
☑	Shaft 3.6	RaiseBored ...	3.6	3.6	$86,...	$4,803	$1,320,...	$15,359	1336070	$2,975,766	$16,199,540	65.0	101...
☑	Shaft 4.2	RaiseBored ...	4.2	4.2	$92,...	$5,404	$1,481,...	$7,132	1488348	$2,964,582	$16,304,120	65.1	101...
☐	Shaft 4.8	RaiseBored ...	4.8	4.8	$98,...	$6,005							
☐	Hora 5.4	Smooth Blast...	5.4	5.4	$15...	$6,606							
☐	Hora 6.0	Smooth Blast...	6.0	6.0	$16...	$7,207							
☐	Hora 6.6	Smooth Blast...	6.6	6.6	$16...	$7,808							
☐	Hora 7.2	Smooth Blast...	7.2	7.2	$17...	$8,409							

Figure 4-12 Example of a Financial Simulation Table

The system relies on the use of accurate mining costs to estimate the costs of different airway sizes and shapes. The correct power cost must also be placed in the Settings.

Input variables required

Airway shapes: Round or Square. A set of 10 airway parameters is stored for each shape type. More complex shapes or fixed areas are not supported at this time.

Life: The life in years required for the airway to be in operation. This directly affects the ventilation operating costs of the airway, and the effect of time value of money.

Discount % : The time value discount of money per annum. The value of money will diminish over the life of project, meaning money saved up front (in most case mining costs) is worth more than money saved in the future (in most cases ventilation costs). Other names associated with factor include the discount rate, project hurdle rate, rate of return or NPV (net present value) discount rate. To use a value of money not diminished by time or to estimate undiscounted future savings, use a zero (0) rate. To evaluate projects however, most mining companies will use factors ranging from 5% to 15%, depending on the cost of money and the competing project values to be gained elsewhere with that money.

Sim : Check this box to include the airway size in the simulation. Airway sizes that are not reasonable or which do not deliver sufficient airflows should not be included for use as they can distort the graphs to excessive ranges.

Fixed Cost : Many airways, such a shafts have an initial setup cost to establish the mining method. This option is included to allow this to be factored in to the overall airway mining costs. It is applied only once for the airway, or group of airways selected, not applied to each individual airway. In most cases, horizontal development will not have a fixed cost applied against it.

Variable Cost :The cost per unit length of development or mining. Using this value, Ventsim Visual™ calculates total mining costs based on the length of the airways selected.

Financial Simulator Outputs

Mining Cost : Total cost of mining airways

Selected Annual Vent Cost :Cost of ventilating selected airways for one year.

Selected Lifetime Cost : Total cost of mining and ventilating selected airways for the life of the airways.

Network Annual Vent Cost: Cost of ventilating whole of network for one year

Network Lifetime Cost : Combined cost of mining selected airway plus cost of ventilating whole of network for life of the airways.

Sel Airflow (avg) : Average airflow through each selected airway

Net Airflow (total) : Airflow through entire mine network.

In most cases, only the Selected Airway costs and graphs will be relevant to the simulation results, however at times it is important to consider the effect of changing airway sizes on the rest of a mine.

For example creating a large shaft to deliver more airflow to a mine, may simply increase the cost of the airflow through other parts of the mine, offsetting some of the expected ventilation savings. For this reason, Total Network ventilation

costs are included as a separate column and graph, and should be considered if the project is an addition to a mature mine.

Fixed or Fans ? When designing networks to a required flow, always use a ***FIXED*** flow for the airways being considered for financial analysis. Using ***FAN*** curves on selected airways, will result in decreasing flow for smaller airways, which in turn, despite increasing fan pressures, may actually result in a decrease in ventilation costs. There is no point in establishing an economic airway size if it does not deliver the required airflow.

> HINT : The financial simulator tools may be useful for examining the airflow capacity of a particular fan on different airway sizes. Even if the financial aspects are irrelevant, the fan performance can be examined to test whether fan flows can be achieved over multiple airway options.

In some cases, a fan may be used where perhaps only one fan option is available, or where the effects of different airways sizes need to be examined on a particular fan performance and cost.

4.6.5 Contaminant Simulations

Simulates the steady state effects and spread of contaminants in the air.

Contaminant Spread **Performs a contaminant simulation based on the position of contaminant source(s) placed in the network.**

Upon completion, the view will switch to a contaminant view with airways coloured according to concentration of contaminants. Contaminant can be placed in a network by using the ***Edit*** toolbar function, or the ***Contaminant*** toolbar button. Contaminant strengths are entered proportional to the airflow they are placed in, and are considered dimensionless.

> EXAMPLE Entering '100' as a concentration value in an airway will result in the dilution of the value as uncontaminated air is mixed downstream. In this case, a value of '25' downstream would indicated 25% of the original contamination strength.

The contaminants may be cleared by pressing the *Clear* button at the base of the contaminant sub-menu.

Contaminant Sourcing **Determines the source of air at a specific location.**

A sourcing simulation is similar to a reversed contamination simulation. It tracks airflow back from a placed contaminant source, and indicates the percentage of airflow which contributes to the airflow through the contaminant marker. This function is useful in determining where a location sources its fresh air from, or for analysing ways to reduce or increase airflow sources from certain areas (such as increasing airflow sourced from a bulk air cooler or decreasing airflow sourced from a production area.)

> EXAMPLE Entering '100' as a concentration value and performing an 'air sourcing' simulation will show which airways upstream are carrying the relative amounts into the original airway. Back tracking the concentrations to the surface will show which

surface airways are providing the airflow and may show values such as (for example) 25% decline adit, 60% main vent shaft, 15% hoisting shaft.

Location Tool **Assist in finding the location of a contaminant source.**

This simulation function was designed to assist in quickly identifying the possible locations of a fire or contaminant source (e.g. dust or production fumes) underground. As people report the status of air from different locations (for example smoky air or clear air), the simulation will colour airways upstream and downstream as either smoke (red), blue (clear) or yellow (possible smoke source)

Contaminant reports can be placed by selecting the location tool bar button under the contaminant button. A ***RED*** pin can be placed to designate a contamination report. Ventsim will assume that all airways downstream from this report will also be in smoke (coloured red) and all airways above the report will be a possible source of smoke (marked in yellow). The ***BLUE*** pin indicates clear air. Ventsim will assume that all airways upstream from this point are in fresh air (coloured blue). Once reports are place, select the location simulation function to simulate and colour the airways around the reports.

As more reports are received, the ***YELLOW*** possible smoke source areas will decrease and the location of a fire or contaminant source can be narrowed.

EXAMPLE Mine Control receives a radio report that smoke has been smelled in a decline location. Checks reveal that other personnel further up the decline cannot smell any smoke.

The vent officer places a 'REPORT SMOKE' tag on the airway where smoke was reported and a 'REPORT FRESH' tag on the clear airways. Pressing LOCATION SIM will show the likely paths of the smoke in RED, what areas are likely to be fresh in BLUE, and what airways may be the source of the SMOKE in YELLOW.

After receiving two more reports of smoke in different areas and fresh air in other areas, the simulation suggests the smoke could only be coming from a workshop area in the mine. The vent officer directs emergency personnel to that area, who find a large number of smouldering rags in an industrial waste bin.

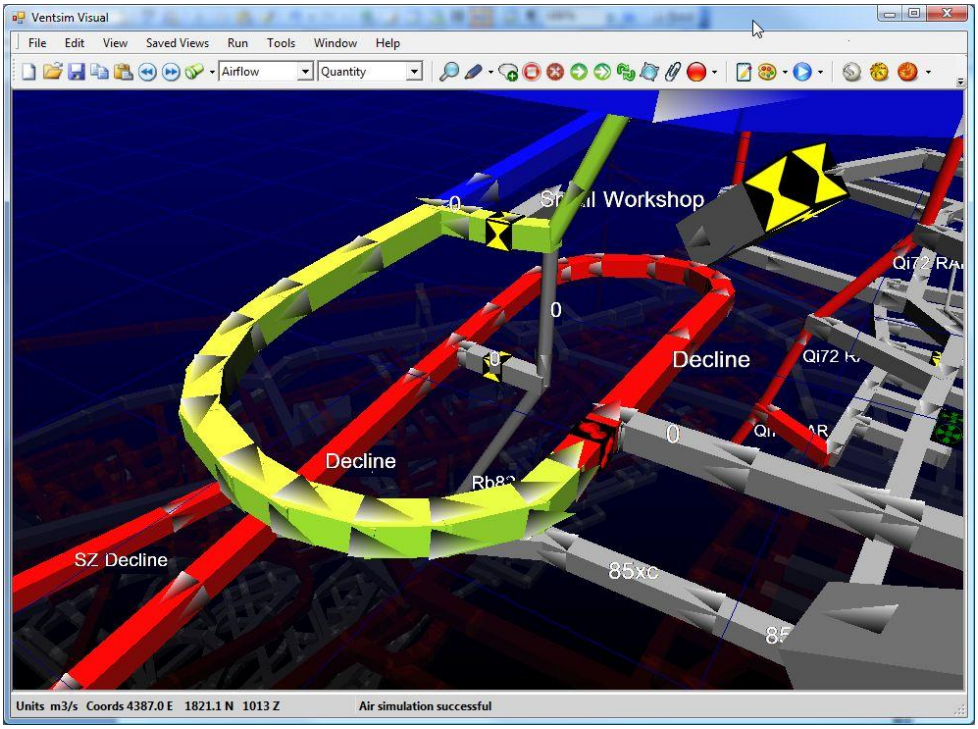


Figure 4-13 Example of contaminant sourcing narrowing down a smoke source.

4.6.6 Summary

Displays a brief summary of your network collectively, or grouped under different *TABS*. The data may be copied to the clipboard, for pasting into another package such as Microsoft Word, or an email.

An example output is listed below from the *Advanced* version with explanations.

NETWORK AIRWAYS	2772	Total number of discrete airways in a network
Total length	66196.0 m	Total summed length of all airways
Total airflow	1025.5 m3/s	Total airflow returned to the surface
Mine resistance	0.00164 Ns2/m8	Cumulative resistance of moving the total airflow through the mine
POWER SUMMARY		
AIR (loss) Power	1772.2 kW	Total theoretical power required to move air through all airways
INPUT Power	3609.2 kW	Total installed electrical power required to move airflow
Consisting of ..		
9 fans @	3607.6 kW	
0 fixed press @	0.0 kW	
2 fixed flows @	1.6 kW	
Network Efficiency	49.1 %	Ratio of theoretical to installed power. Network efficiency will decrease as more fans are required to boost airflow through mine. Placing fans in series (i.e. boosting) accumulates fan efficiency losses at each stage of the fan.
NETWORK FAN		

SUMMARY		
Fan Installations	7	Total fan installation in network
Fan Numbers	9	Total number of fans in network
Fan Sites Switched Off	0	Fans turned off
Fan Sites Stalled	0	Fans operating at their maximum pressure
Fan Sites Low Pressure	1	Fans operating at a pressure beneath the lowest fan curve pressure, but still above zero
Fan Sites Negated	0	Fans running with no or negative pressure added
Fans running reversed	0	Fans running in reverse (user selected)
Total fan power	3607.6 kW	Total of all fan electrical power. The is calculated from fan shaft efficiencies, and motor efficiencies. The fan power is calculate from the fan power curve. If the curve is unavailable, it is estimated from the fan total efficiency curve. If this is unavailable, the default fan efficiency is used.
HEAT & MOISTURE INPUT SUMMARY		
Diesel Sources	0.0 kW from 0 sources	Sources of diesel heat and contaminants
Sensible Heat Sources	0.0 kW from 0 sources	Sources of sensible (dry) heat
Linear (S) Heat Sources	0.0 kW from 0 sources	Sources of heat distributed along multiple airways
Latent Heat Sources	0.0 kW from 0 sources	Sources of latent (vapour) heat
Oxidisation Heat Sources	0.0 kW from 0 sources	Sources of oxidising heat
Electrical Heat Sources	3609.2 kW	Sources of electrical heat
Total Input Heat	3609.2 kW	Total heat input from man-made influences
Total Strata Heat	2885.1 kW	Total heat input from heat dissipated from rock
TOTAL HEAT SUMMARY	6494.3 kW	Summation of all heat
Total Refrigeration	0.0 kWR from 0 sources	Refrigeration installations
HEAT BALANCE TOTAL	6494.3 kW	Summation of heat minus refrigeration
Moisture Point Sources	0	Number of point moisture sources (such as conveyor dust suppression spray)
Moisture Linear Sources	0	Number of liner moisture sources (man made, such as decline dust sprays)
Moisture Input as Latent	0 ml/sec	Summary of moisture added from latent heat sources (such as diesel engines and latent point sources)
Moisture Airway Surfaces	4404 ml/sec	Summary of moisture evaporated from rock strata
Network condensation	0 ml/sec	Summary of moisture condensed as water (normally in upcast exhaust shafts)
MOISTURE	4403 ml/sec	Total moisture exhausted from mine.

EXHAUSTED		
HEAT AUDIT		
Input heat below surface	6454.5 kW	Check to make sure heat exhausted from mine, is accounted for from summation of underground heat sources.
Elevation adjustment	29.5 kW	Adjustment due to inlet / exhaust elevation differences (auto compression)
Differential inlet to outlet	6469.9 kW	Different between inlet from surface heat, and exhaust to surface heat
Potential heat imbalance	14.1 kW (0.2 %)	Error between the underground inputs and the surface recordings
Potential temp imbalance	0.00 C degrees	Potential error in temperature as a result.

Figure 4-14 Example of Summary Output with Description

Heat Audit errors normally occur due to changing air densities during the heat simulation, not been reflected in slight changes in air and mass flow. This small error is corrected next time the simulation is run, however the next simulation also adds slight changes to density, and hence the error is never truly eliminated.

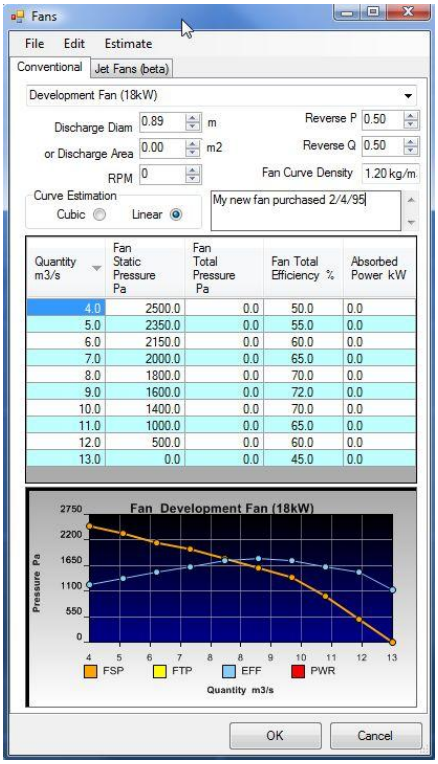
How much Heat Audit Error is too much?

It depends on the network and tolerance for temperature margins, however up to 5% is generally acceptable, and will only give a slight imbalance in temperatures. Errors beyond 5% should be investigated to ensure major recirculation, or some other heat imbalance is not occurring in the model.

4.7 Tools Menu

A selection of tools and settings to check, modify and fine tune the network

4.7.1 Fans



Displays a dialogue window which allows editing, adding and deleting of all fans in the network fan database. Up to one thousand (1000) fans and the associated fan curves may be entered into the fan database. A display for each fan curve and data will be presented when a fan is selected from the display list.

The Edit > copy and paste functions can be used to copy data to or from another program (for example a spreadsheet).

Caution should be taken when deleting or modifying a fan, as any network which may have used that fan number, will still attempt to use that particular number fan's data. If the data is not present, or is different, the network will not simulate properly.

Figure 4-15 Fan Curve Entered into Ventsim Visual

The fan name is entered or chosen at the top from the pull down menu. To enter a new fan, select *File > New*

At a minimum, fan curve points for quantity and either fan static or total pressure must be entered for each fan. Other curve information such as efficiency and power can also be entered to assist Ventsim Visual™ in estimating fan power and heat.

Density **Density** is an optional parameter, which will be assume a default value if not specified. In Ventsim Visual™ Advanced, fan performance is adjusted for density changes in the mine. Most manufactures supply their fan curve at a standard density, however different densities can be entered for your fan curve if required.

Diameter **Diameter** is also an optional parameter describing the exit diameter of a fan. This may be the diameter of the fan casing or an evasé if fitted. Ensure the fan curve entered is for the specific fan configuration (check with your fan manufacture for this). Adding or removing an evasé from a fan for example can significantly change the fan performance (although the fan total pressure curve will remain the same). Where only a static curve is available, the diameter can help estimate fan total pressure and the associated power consumption.

Where only fan total pressure is entered, the fan diameter can help estimate available fan static pressure, a consideration for surface exhaust fans. Finally, the fan diameter can also help estimate new curve points for the fan database, if either the fan static or total curve is unavailable. See the fan database section for more information.

Hint: It is recommended where fan pressure curves are provided without the modelled effects of an evasé (which is normally how fan manufacturers provide the curves as mines may mount the fan in different configurations), any evasé effects should be independently modelled by using the edit box options to place an evasé in the airway, not by changing the fan diameter or curve behaviour.

Fan speed **Fan speed** can be individually changed at different fan locations, and will calculate the theoretical fan performance difference at different speeds. Note that this is a theoretical estimate only, and may become less accurate where extremes of fans speeds are used.

Fan Reversal **ReverseP** and **ReverseQ** modifies performance for fans run backwards for an emergency situation. Most manufactures will not supply these figures as fans are not generally designed to do this (although some fans can be designed to perform better in reverse than others). These figures ideally need to be derived experimentally be measuring actual fan performance with blades running in reverse. Ventsim Visual™ initially defaults to 0.5 for both (50% of maximum pressure and 50% of maximum airflow).

Curve Estimation The method used to estimate curve data between specified fan duty points. The **cubic spline** method estimates a curved data path between fan points. If only a few points of data are available, this may produce a better estimate of fan duty, however the method may be limited by sudden changes in curve data point direction. Ensure sufficient points are available to produce a smooth non-reversing curve.

The **linear method** predicts a straight path between points. This method is slightly faster during simulation, and if the maximum number of fan points (10) are entered, it should provide sufficient accuracy in most cases.

> HINT: It is important that pressure on the curve is not permitted to bend over in a U shape (or upside down U), otherwise the simulation may oscillate between two pressure points. Stall regions of fans should be omitted for this reason.

Comments **Comment box** is included to describe more information about the setup or configuration of the fan.

Point Table **Fan Point Table** : The table will allow direct entry of fan curve data. Fan curves will be constructed as data is entered. Points can be submitted non-sequentially, and will be automatically rearranged when the fan is re-loaded or saved.

To calculate fan power within a network, Ventsim Visual™ needs either a fan efficiency curve or a fan power curve. If neither of these curves are available, the default fan efficiency will be used from the Settings menu. If *both* efficiency and power curves are entered, Ventsim Visual™ will *preferentially* use the fan power curve to calculate absorbed fan power.

Should I Use Static or Total Pressure? Most fan manufactures supply one or both of the pressure curves. Ventsim Visual™ differs from Ventsim Classic 3.9 in that it has an option in the Settings – Air Simulation menu to universally use fan total pressures (FTP), fan static pressures (FSP) or a mixture of both.

Using FSP curves will ignore the fan velocity pressure (FVP) portion contribution to network pressures, but will also ignore any system exit velocity losses to surface throughout the network.

Using FTP curves will include the FVP portion, but will include system exit velocity pressure losses as part of the network system total pressure.

More information is available in the Settings Chapter.

The case for Fan Static Pressure Simulation

It is technically correct for simulations to use fan total pressure (FTP) curves for fan installations. Fan total pressure however is not always converted into useful ventilation energy due to outlet losses from fan installation configurations.

Traditionally, Ventsim Classic 3.9 has encouraged users to utilise fan static pressure (FSP) curves for modelling, (although FTP curve modelling was included as an option). Using FSP curves excludes the velocity (dynamic) component of fan pressure curve which is therefore assumed not to contribute to the overall system pressures in a network simulation. To partly offset the lack of fan velocity pressure inclusion, the system exit velocity pressures (the velocity pressure loss to the network from air exiting from shafts or other exhaust airways) are also not included by Ventsim Classic 3.9 in calculating overall system pressure. While these two factors partially cancel each other out, using *Static* curves for underground fans is likely to give a slightly conservative system pressure and airflow if fan exit (shock) losses are modelled identically for both an FSP and FTP case.

When designing a network, this may be advantageous to provide contingency for design simulations. In addition, use of FSP curves is less reliant on accurately

modelling fan exit shock losses, and provides a greater contingency for design airflow. In general, they may be more suitable to use for a less experienced user.

The case for Fan Total Pressure (FTP) Simulation

FTP Simulation will allow Ventsim Visual™ to utilise the full fan total pressure curve for network system pressures. Provided fan exit shock losses are modelled to consider the fan installation and exit airflow orientation, then this method should provide more accurate results. In addition, as Ventsim Visual™ will consider system exit velocity pressures when FTP modelling is selected, fan exit diameters, airway surface exhaust sizes or evasés sizes are adjusted to simulate the effect of on surface exhaust airways and mine system pressure.

Note: Increasing fan diameters or including evasés in Ventsim Visual™ for underground installed fans will have no automatic effect on network simulation results, as it will not change the surface velocity pressure exit losses. It may however decrease shock losses at the fan exit, which if modelled in Ventsim Visual™ by changing airway shock loss will result in improved fan performance.

Evasé Hint: If the Fan Total Pressure Method is chosen, the effect of evasé size on surface exhaust shafts can be easily examined. Simply click on the surface airway, and select evasé and place a size. The size must be larger than the original airway. Alternatively, you can construct a short enlarged surface connection airway which will produce a similar effect to including an evasé option in an airway.

In Summary

In most cases, if fan exit shock losses are modelled with the same factors, the **FTP** pressure method is a more accurate method and will deliver slightly more airflow through a mine. This may or may not be significant for your model and should be considered when examining the overall contingency built into the model.

Estimate Tools Menu The tools menu contains a number of functions to assist in estimating fan static or total fan curves as if either one is unavailable, as well as fan total shaft efficiency and fan absorbed power if either one is unavailable. This may be required if only a Fan Static Pressure (FSP) curve is available, and you wish to simulate the network using a Fan Total Pressure (FTP) curve.

Ventsim Visual™ will use the outlet diameter of the fan to calculate the velocity exit pressure of the fan, and thereby calculate the missing static or total pressure curve. To estimate absorbed power, Ventsim Visual™ will calculate theoretical power using total pressure and airflow. Note that none of these estimation methods take into account shock losses, resistance and compression factors which will slightly affect calculated pressure and powers. It therefore should be used as a guide only, and is no substitute for an accurate fan manufactures curve if available.

Estimate Fan Curve Quickly estimates 10 evenly spaced points of fan curve duty from as few as 3 entered points. The estimation method will use the Cubic Spline method to add the additional points. This method should only be used if additional fan curve data is not accurately available.

4.7.2 Levels

A list of elevation ranges on which airway data can be individually viewed.

A dialogue window is displayed which allows editing or creating of a list of levels (elevations) between which airway data is located. The level list can contain up to 1000 levels on which your network will be created.

Elevation data can be edited in any order, as well as added at a later date - Ventsim will sort the data from highest to lowest when next displayed.

To select which levels are displayed, choose the *View Options* toolbar button, *Select Levels* and click which levels you want to display. Alternatively, levels can also be independently set by using the mouse context pop-up menu (right mouse button on the screen) to *Select Levels*. Level can be chosen by clicking or fencing a range of elevations, and then *Right Click* the screen to commit those changes.

To view ALL levels at any time, simply use the *Right Click* pop-up menu to select **All Levels**.

4.7.3 Spreadsheet

Displays a list of currently viewed airways in a spreadsheet form.

A READ ONLY spreadsheet of airway data is displayed which can be copied and pasted to other applications such as Microsoft **Excel** or **Word**.

Up to 70 different types of data can be displayed on the spreadsheet. To display different data types, use the SELECT > DATA OPTIONS menu to select which data you wish to display.

Data can also be removed from the spreadsheet, by selecting EDIT > REMOVE or using the right mouse button.

Data columns can be reordered by selecting the column title and dragging to a new location. In addition columns can be resized and resorted by using the appropriate menu commands.

> **Hint :** The spreadsheet function is not designed for editing data. Extensive data characteristics for each airway can be displayed, and copied to external programs such as Microsoft Excel ™. Ventsim Visual provides an Index number and a Unique number reference for each airway. The Index number is referenced internally and during simulations by Ventsim Visual, but may changed for each airway as airways are added or removed. The Unique number will not change, and should be used as a permanent reference number to each airway if other identifiers such as names are not used.

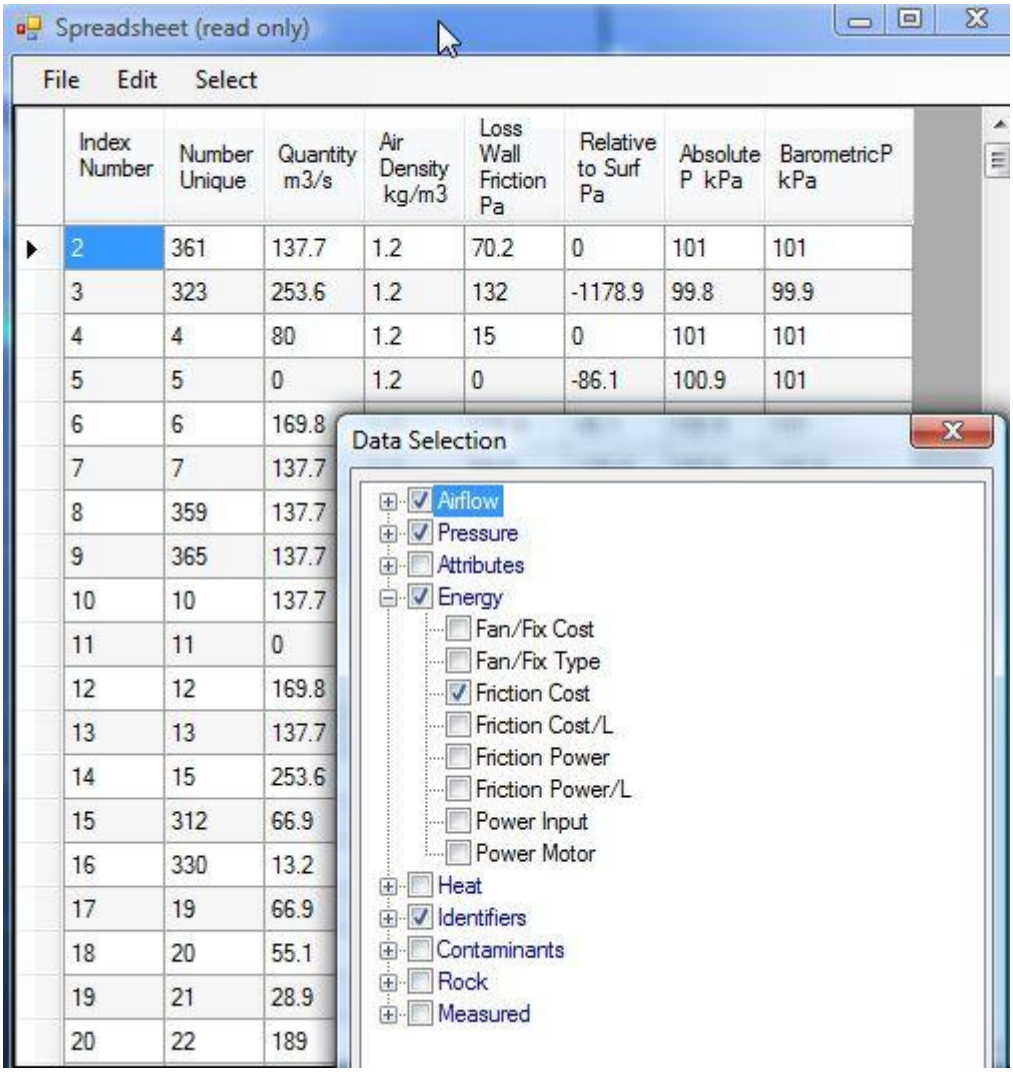


Figure 4-16 Spreadsheet view of network with selected data

4.7.4 Utilities

The utilities sub menu provides many functions to assist with manipulation of airway data, particular raw data which may have been input from a DXF import or similar.

4.7.5 Filtering Tools

Filtering tools consist of a selection of airway utilities to help correct overly complex, disconnected or overlapping raw network data. The tools can be run simultaneously as a group, or individually.

The All Tools tab in the form, allows simultaneous filtering using the various selected tools. Alternatively, each tool can be selected and run individually from the other tabs.

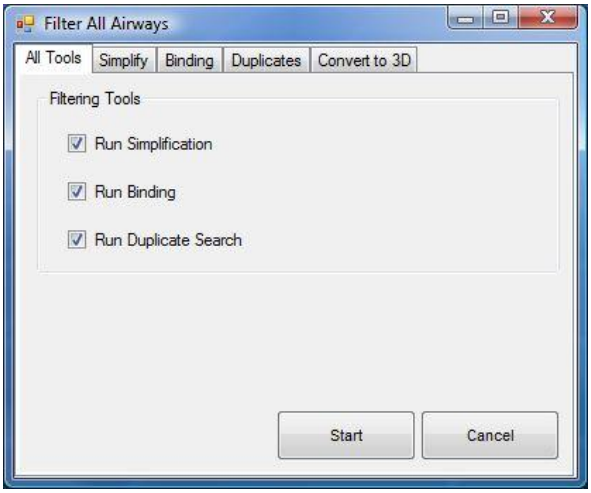


Figure 4-17 Filtering Tools Combined

Simplify allows the user to reduce the number of airways in a network to a more efficient number without affecting the overall network analysis.

It is particularly useful where a network has been imported via a DXF file and contains a large number of very detailed but unnecessary small connected airways.

Simplify will search a network for sequences of airways that may be reduced to a single straight airways. In doing so, much of the overhead and effort required to set parameters to every airway can be reduced. Note that the simplify function will only combine airways that have a single entry and exit. Airways at junctions and split branches will remain untouched.

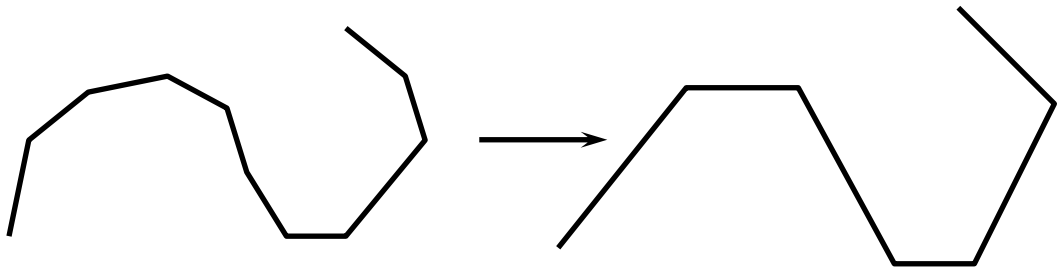


Figure 4-18 Example of a line string 'simplified'

Note in the previous example, 10 airways are simplified to 6 airways without affecting the integrity of the network.

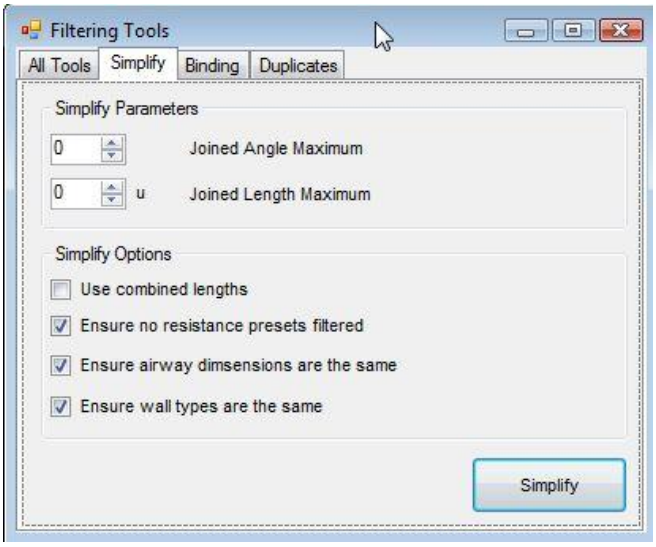


Figure 4-19 The simplify dialog box

Maximum Joined Angle

The ***Max Angle*** option specifies the maximum angle between two airways being considered for merging. For example, if the original network contains a number of airways that form a curve and ***Max Angle*** is set to 20 degrees *Simplify* will keep on merging airways until the airways being considered have directions changed by 20 degrees or more.

Maximum Joined Length

The ***Max Length*** option restricts only airways with lengths up to the value length from being combined. For example if set to 30m, only airways with lengths of less than 30m will be considered for merging and simplifying.

In general, the higher the values of the ***Max Angle*** and ***Max Length*** settings, the more aggressively Ventsim Visual™ will seek and combine airways.

Use combined lengths:

Ensure the new length of a combined airway is fixed to remain exactly the same as the original combined lengths *even if the original airways formed a curve*. If not set, the new lengths will be recalculated as the true length of the new straight line.

Ensure no resistance presets filtered:

Ensures that airways with a preset resistance (such as a bulk headed airway) are not simplified and merged with other airways.

Ensure airways dimensions are the same:

Check to see if airways that are considered for merging and simplifying are only joined if they are exactly the same size.

Ensure wall types are the same:

Similar to dimensions, only airways with similar wall (friction factor) types are joined.

Selected airways only:

Only simplify selected airways and ignore all others.

HINT : Short irregular airway segments are best simplified with high joined angle settings (+45 degrees) or smaller joined length settings (<20m). Long smooth airway segments are best simplified with low joined angle settings (<20 degrees) and high joined length settings (>50m). Note that airway can be individually or group selected for simplification.

4.7.6 Binding

Binding connects disconnected airways ends or intersections. Many imported DXF files do not have correctly connected centre lines or ends. This function will search for unconnected ends or crossed airways and join them together if they are close enough. Airways must always be correctly joined to allow air to flow

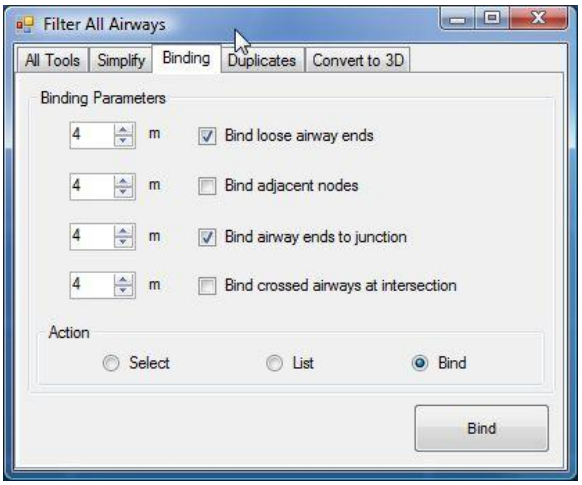


Figure 4-20 Binding Tools

Bind loose airway ends
Defines the distance to join airway ends in a network which are close together but do not join. Imported DXF file commonly have airways which don't exactly join due to editing or drawing inaccuracies in the original file. Airways which do not exactly join in Ventsim Visual will not flow air, and will result in a No Ext / Entry warning.

The search radius can be entered in the preset box. For example a search radius of 4 will join any loose node (airway end without another connection) to any airways within 4m of another node.

Warning : This function is intended for preliminary cleanup of new networks, not for existing balanced networks. It can permanently change the characteristics of your network and may delete some preset items of values.

Bind adjacent nodes
Defines the distance to join adjacent connected nodes in a network which are close together but do not join. This function is a little like simplify, in that small airways between the joined nodes will be removed.

Warning : Selecting this option with too greater distance can seriously distort the model. Use with caution or not at all.

Bind airway ends to Junction
Defines the distance to join airway ends to nearby airways which do not have a node or end. It effectively splits and joins into the new airway. Imported DXF file commonly have airways which cross the path of airway ends, but do not have a joining node. This function will create a joining node. Airways which do not exactly join in Ventsim Visual will not flow air, and will result in a No Ext / Entry warning.

Warning : This function is intended for preliminary cleanup of new networks, not for existing balanced networks. It can permanently change the characteristics of your network and may delete some preset items of values.

Bind Crossed Airways at Intersection
Defines the distance for joining airways which intersect or come close to intersecting, but do not have a joining node. It effectively splits and joins both airways into new airways. Imported DXF file commonly have airways which cross the path of another airway, but do not have a joining node.

4.7.7 Duplicates

Searches for airways which have duplicates in the same or similar position. Duplicate airways can cause problems with air simulation do to poorly defined or hidden flow paths that the user cannot see.

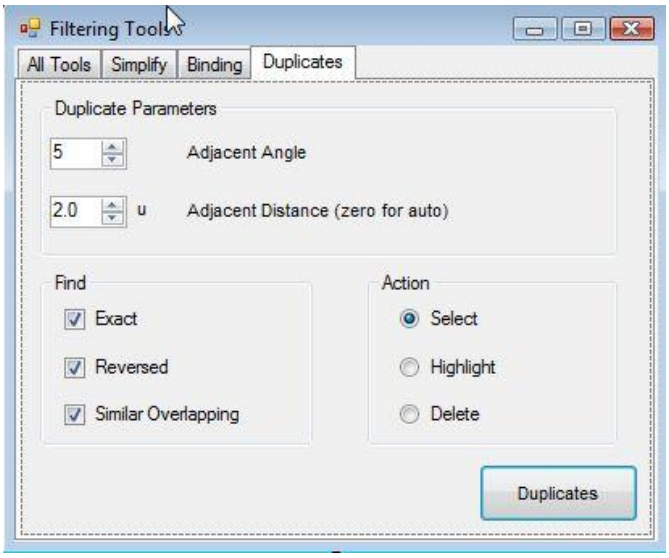


Figure 4-21 Duplicate Finding Tools

Adjacent Angle is the maximum angle difference between adjacent airways that may be considered as a duplicate. Airways next to each other with greater angles between them will not be considered as a duplicate. The smaller the angle in degrees, the more 'parallel' and airway must be to be considered a duplicate.

Adjacent Distance is the maximum distance two adjacent airways can be apart before they will no longer be considered as duplicates. The smaller the distance, only closer airways will be considered.

Exact select only an exact matching airway as a duplicate

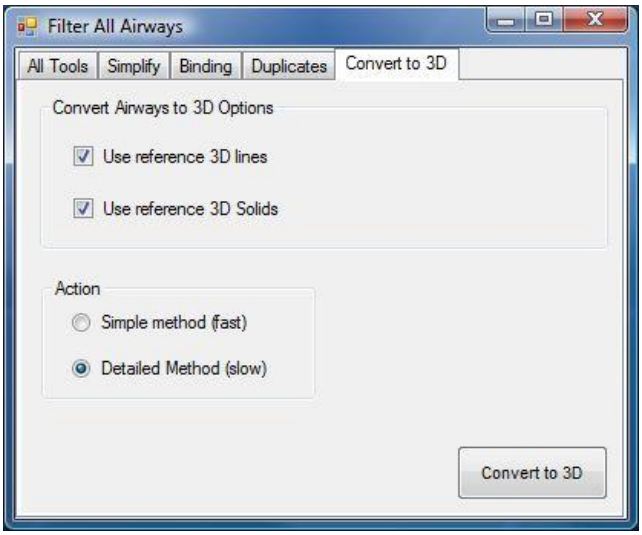
Reversed selects airway the same, but facing opposite directions.

Similar selects airways similar but not identical. The adjacent angle and distance will be used as a criterion for selection.

Action defines what action will be taken when the duplicate airways are found.

4.7.8 Convert To 3D

Moves the model airways on to a 3D surface or contour plan, effectively converting the model from a 2D plan to a 3D model. Note that if only parts of a model are to be converted, they should first be selected with the Select tool



Use Reference 3D Lines : Uses lines (such as contours) loaded in from a DXF as a reference to convert the model to 3D.

Use Reference 3D Solids : Uses solids (such a terrain polygons) loaded in as a referenced DXF object, to convert the airways to 3D,

Simple Method : A fast method which searches the closest 3D reference point. Suitable for relatively flat conversions

Detailed Method : A slow method which searches for the closest vertical intersection. It is more suitable for rugged 3D surface conversion.

HINT : To convert a multi seam of level model to 3D using this function, individually group select the airways required, and ensure only the relevant 3D DXF object for that level is turned on before conversion.

4.7.9 Select Loose

Selects any airway with one or both ends not connected to another airway. The selected airways can be deleted or edited and set in the EDIT box (for example) to 'allow open ends'. Loose ends such a dead end heading stubs (like truck bays or sumps) often do not carry air and can be deleted from the network quickly with this function.

4.7.10 Swap Axis

Reverses the Easting and Northing coordinates. This may be useful where the coordinate system in Ventsim Visual™ does not match the directions used on the Mine Plan Grid. Where the direction of the coordinates needs to be reversed, use the Settings > COORDINATES settings to change direction of the axis coordinates.

4.7.11 Scale Coordinates

A utility which scales all airway coordinates by an input factor. This effectively reduces or increases the size of the network without changing the airway size. The airway length will not be changed if it has been fixed.

Warning this function should only be used to scale schematic ventilation network with predefined fixed airway lengths. Scale a network without fixed length will change the airway length and resistance, making it invalid for true scale network simulation.

4.7.12 Scale Airway Size

A utility which scales all airway dimensions by an input factor. This effectively reduces or increases the size of the airways in the network.

Warning this function will rarely find a practical use. Scale network airway sizes will change the airway resistances, making it invalid for true scale network simulation.

4.7.13 Airways

Modify a selection of airway specific parameters

Lengths Fixes or un-fixes airway lengths, so that networks may be manipulated without changing the calculated airway lengths.

Fix All Lengths This will fix and protect all airways in the network from changes in length when moving airways. This may be useful if airways are required to be moved for clarity, but lengths must remain the same.

Unfix All Lengths This will un-fix and recalculate all airway lengths in a network.

This function will recalculate airways lengths and hence change any previously fixed lengths. If there are any doubts, use the EDIT function to individually fix/unfix lengths of only the airways that need to be changed.

4.7.14 Auto Name

Automatically places a code number on every airway without a current airway name. A letter may be specified to head the number if desired (e.g. B157).

4.7.15 Limit Display Data

Helps reduce text data shown on screen.

This function search selected airways (or if no selection made, all airways) for continuous airway segment groups without junctions, and limits data display to only one of those airways. When the menu item TEXT DATA > LIMIT DISPLAY is selected under the VIEW menu, the display will only show text data on the single airway segment.

HINT As many continuous airway segments show similar data (such as airflow amounts), reducing text display to just one airway per segment group can significantly reduce text clutter on the screen. If the automated function does not select the desired airway to show the data, simply EDIT the desired airway an check ALWAYS SHOW DATA.

4.7.16 Resequence Index/Unique Numbers

Resequences the order of airway numbers in a Ventsim Visual™ network.

Index numbers are dynamic numbers representing airways stored internally in Ventsim Visual. The numbers may change as airways are deleted or added. Ventsim Visual™ uses Index numbers to refer to airways during simulation and when indentifying problems. All index numbers are sequential and the highest index number will be the sum of all airways. Resequencing index numbers renumbers all airways from higher elevation to lowest elevation, easting to northing.

Unique numbers are static numbers which do not change when airways are deleted or added. Numbers are sequenced incrementally from the last highest unique number. As such, as airways are added and deleted, there may be large gaps of numbers between airways. Unique numbers are a useful reference to identify the same airway as the network is developed. Resequencing the unique numbers renumbers all airways from number 1, sequentially top to bottom to the last airway.

HINT Resequencing numbers is not a requirement in Ventsim Visual, but may simplify tracking airways, as the resequence function tends to group airways in similar locations with similar numbers. This is particular handy in the SPREADSHEET function which initially lists airways in sequential index order.

4.7.17 Troubleshoot

This option allows detailed checking of networks, and will identify areas of your network that may cause problems during the simulation process. A network with too many redundant bulkheads (bulkheads in the same airway path as other bulkheads), or fans that are in the same airway path as other fans, may result in a network that will not converge.

Restrictive Fans: Finds and alerts the user to fans that are directly competing against other fans.

Unnecessary Bulkheads: Finds and if desired remove bulkheads that are not necessary (usually because another bulkhead in the same airway has already stopped the airflow).

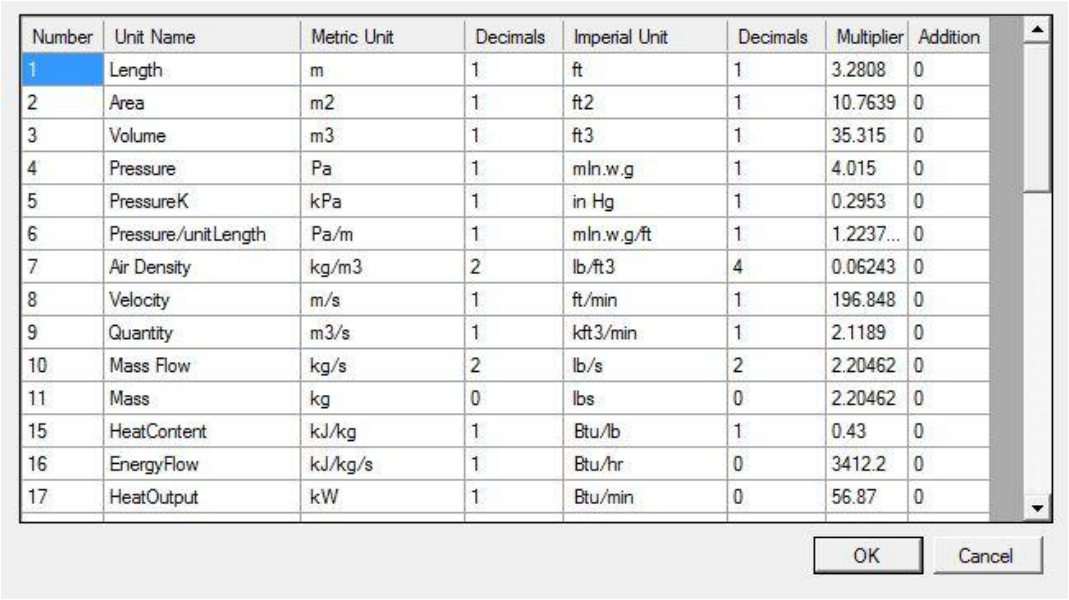
Reset Network **Removes all airflow and temperatures from a network.** The simulation processes is restarted with fresh data. Ventsim Visual™ utilises flows, densities and temperatures from previous simulation to help it to recalculate new simulations faster and more accurately. If data has been corrupted during a bad simulation (which may have produced errors, excessive airflows, heat or densities), this may hinder subsequent simulations from finding an acceptable solution, or may simply produce further errors.

Resetting the network will remove all calculation flows, pressures, densities and heat. It will **NOT** remove any values fixed by the user, such as fixed flows, pressures or heat sources.

Conversions **Sets the metric and imperial conversion units and factors used for Ventsim Visual, as well as the number of decimal points to show on the display.**

The conversion table displays the metric and corresponding imperial units for each type of data used in Ventsim Visual. The table is saved with every network, and can be individually modified for each network file. The conversion settings can be inherited by other networks or saved in a template file.

The imperial unit names and factors may be freely changed to suit the region or preference of the mine. The imperial column in the table may even contain metric units if required, by setting the imperial unit name to a metric text value and a conversion factor of '1'.



Number	Unit Name	Metric Unit	Decimals	Imperial Unit	Decimals	Multiplier	Addition
1	Length	m	1	ft	1	3.2808	0
2	Area	m2	1	ft2	1	10.7639	0
3	Volume	m3	1	ft3	1	35.315	0
4	Pressure	Pa	1	mln.w.g	1	4.015	0
5	PressureK	kPa	1	in Hg	1	0.2953	0
6	Pressure/unitLength	Pa/m	1	mln.w.g/ft	1	1.2237...	0
7	Air Density	kg/m3	2	lb/ft3	4	0.06243	0
8	Velocity	m/s	1	ft/min	1	196.848	0
9	Quantity	m3/s	1	kft3/min	1	2.1189	0
10	Mass Flow	kg/s	2	lb/s	2	2.20462	0
11	Mass	kg	0	lbs	0	2.20462	0
15	HeatContent	kJ/kg	1	Btu/lb	1	0.43	0
16	EnergyFlow	kJ/kg/s	1	Btu/hr	0	3412.2	0
17	HeatOutput	kW	1	Btu/min	0	56.87	0

OK Cancel

Figure 4-22 Conversion Table

Decimals **Sets the number of decimal units to display on the screen and in text displays.**

Example A value of three (3) for example will display a value of 23.123 on the graphics display, or in the spreadsheet view.

Caution While the metric unit text name can be changed, the underlying metric value cannot be changed. For this reason, the units must remain the same as preset in Ventsim. For example, the Velocity cannot be changed to km/hr as this would represent a different value scales, and the underlying Ventsim equations are hard corded to use m/s.

Imperial Unit **A text name describing the imperial units.**

Multiplier **The factor used to convert from metric to imperial**. Ventsim Visual™ performs all internal calculation using metric formula and methods, converting displayed data back to imperial (if set in SETTINGS). The factor is used to convert to and from metric to imperial, and will result in errors if not properly set.

Addition **This factor is only used in converting degrees Celsius to degrees Fahrenheit**, and added to the metric value before multiplied in imperial.

4.7.18 Presets

A list of preset factors and characteristic used for placing in airways.

- Presets include
- Resistances
- Friction Factors
- Shock Factors and Equivalent Length
- Heat, Refrigeration and Moisture Sources
- Layers
- Air Types

- Fans (limited to header information only)

Values entered into the spreadsheets will be made available for attaching to existing airways from the Edit box. Updating existing values in the preset spreadsheet will automatically change all airways with that preset on the next simulation.

Warning : Be careful when removing existing settings from the preset spreadsheet. Settings removed which already belong to an existing airway, will force the airway to 'set' the values permanently.

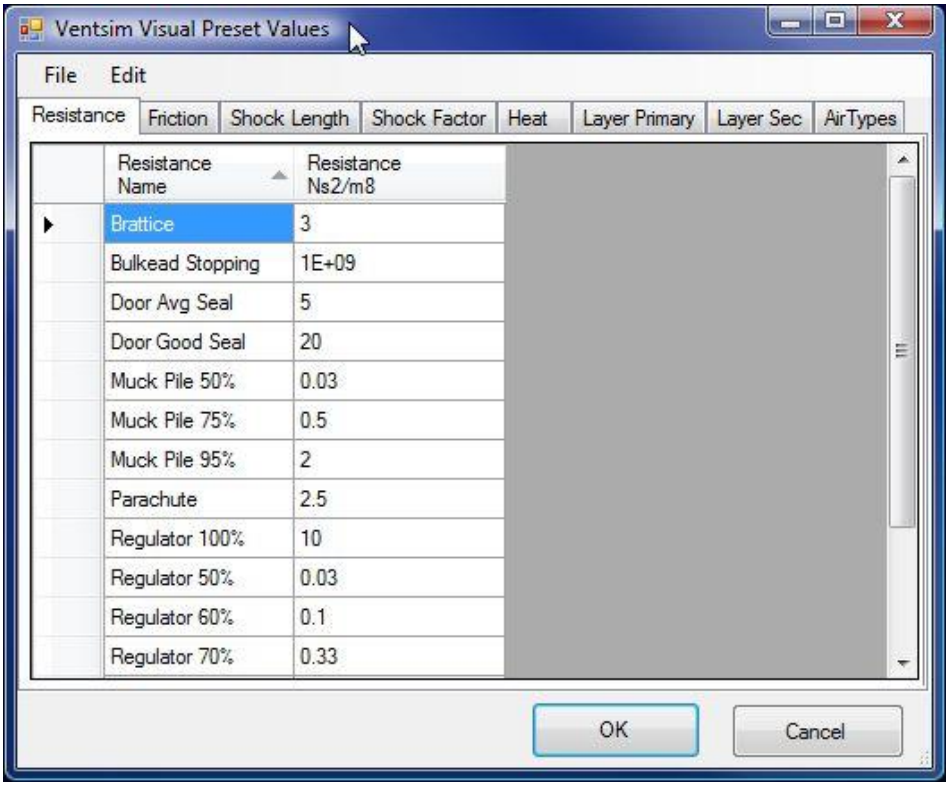


Figure 4-23 Preset Table Options

4.7.19 Settings

An extensive list of settings used by Ventsim Visual™ that controls the behaviour, simulation parameters and visual appearance of the program.

Settings are divided into a number of categories, including.

Category	Description
Airway Defaults	Controls parameters of the simulation process for airflow
Colours	Colours of the background and text used for display
Graphics	Visual appearance of graphics, sizes of objects and text on screen

Heat Physicals	Actual parameters of air and rock conditions used in simulation
Model Coordinates	Coordinates and grid systems used for the network
Simulation – Heat	Controls parameters of the simulation process for heat
Simulation – Airflow	Controls parameters of the simulation process for airflow
Ventsim Main	The program control settings

For further information on settings, go to the settings sections

4.8 Windows Menu

4.8.1 Fit All Fits all display data on the screen.

4.8.2 Zoom Out Increase the distance away from the window point of focus. This may be of use if the mouse used does not have a scroll wheel.

Chapter 5

Chapter 5 PRESETS

5.1 Preset Values

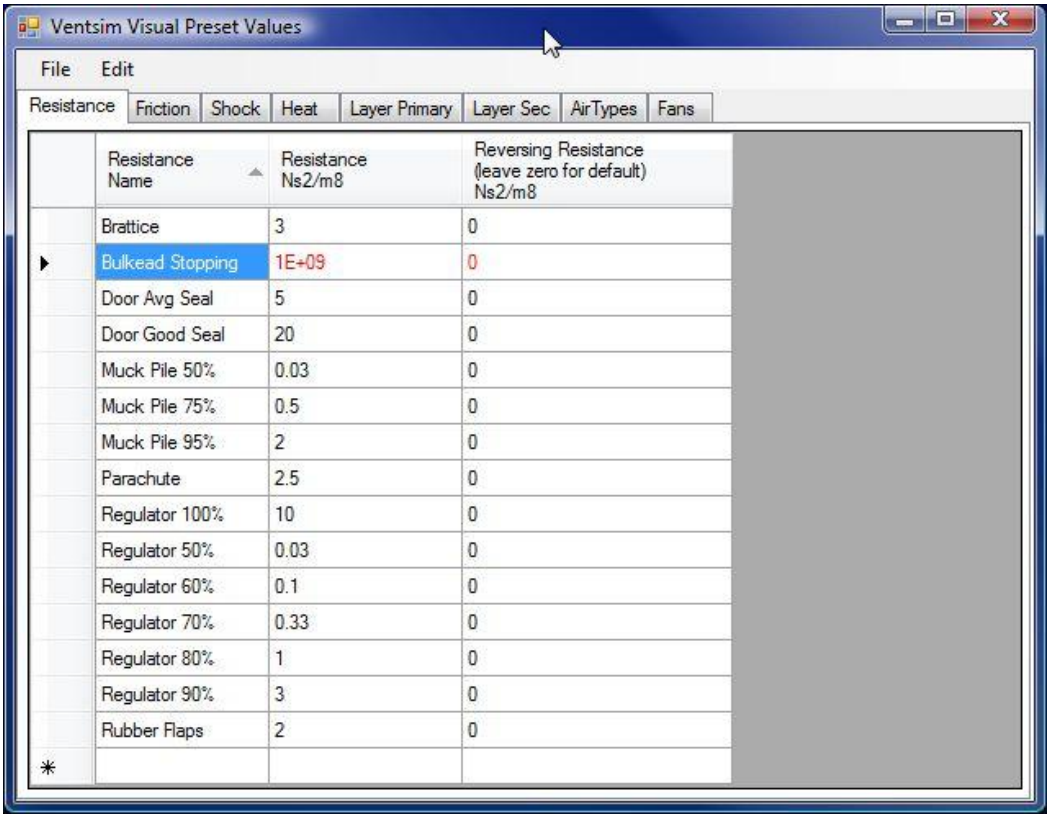


Figure 5-1 Preset Settings

Preset values provide a quick and convenient way to specify airway characteristics and parameters that may be commonly used in the ventilation network. Examples are resistances (such as doors or seals), common wall friction factors, shocks losses, heat sources.

The preset table also gives access to network primary and secondary layers, as well as air types and fans.

5.1.1 Preset Values

Any preset value which is changed will be applied to ALL airways using that preset value. For example if a network has 10 airways using a resistance preset called 'Rubber Flaps' and the resistance for 'Rubber Flaps' is changed in the preset box, then ALL 10 airways using rubber flaps will have the new resistance applied.

Most items can be deleted by selected the entire row (or a number of rows) and pressing DELETE, or by selecting and deleting individual values. If a preset is currently in use, a warning may appear stating the fact, and the result it will have on the network. Ideally, presets should not be removed if they are currently in use.

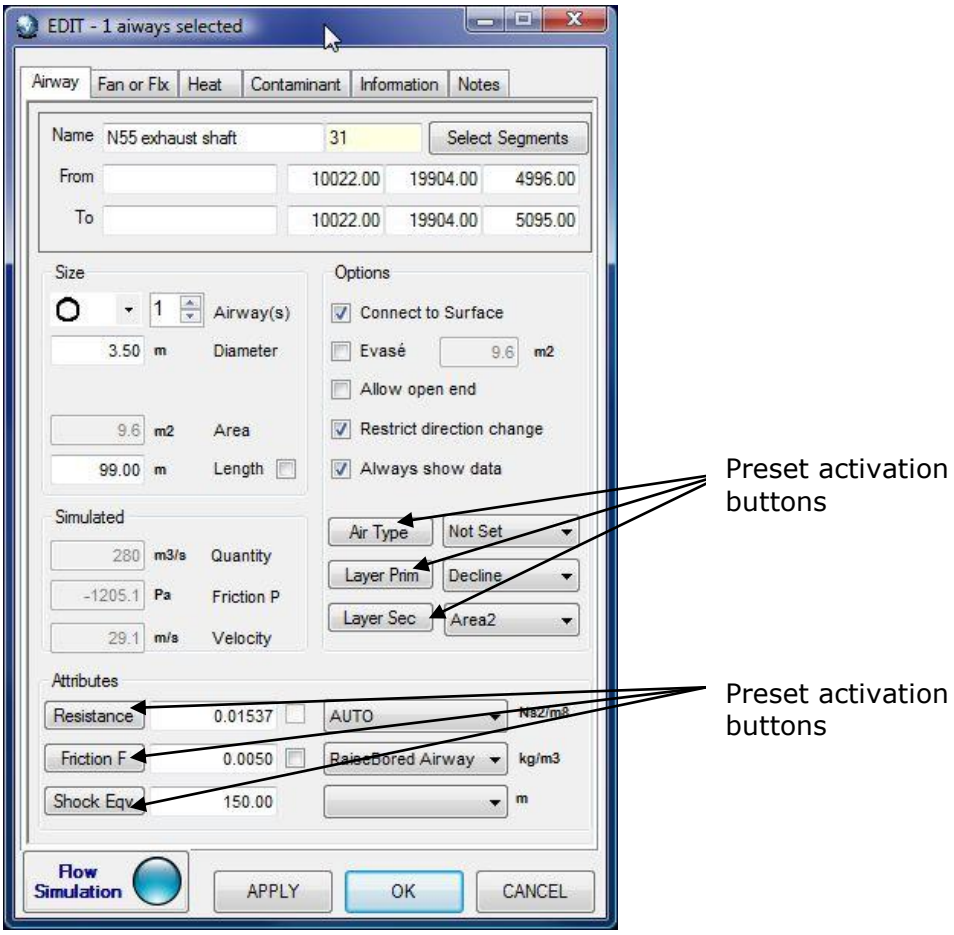
5.1.2 Sort Order

The sort order of the preset values displayed in the spreadsheet, and displayed in forms in other parts of the program can be specified in the form. All columns in the preset form can be sorted by Ascending or Descending by clicking the column header once or twice. For example, resistances can be sorted by name (by clicking the 'Resistance Name' column header, or by value (by clicking the value header).

In addition, row items can be manually sorted, by selecting the row and pressing the UP or DOWN arrow on the keyboard. The sort order will be retained next time the form is accessed and will be saved with the file.

5.2 Accessing Presets

The preset form can be accessed from the TOOLS menu, or directly from the EDIT form, by pressing the appropriate preset button. When activated from the EDIT form, the currently used preset will be highlighted in the Preset form.



5.2.1 Resistance

Up to 100 different resistance presets can be entered. Resistance presets can be applied to airways from the EDIT form. Any resistance entered in the preset will be applied to an airway during simulation.

It is important to note that underlying airway resistances due to wall friction WILL ALSO be applied in addition to the preset resistance. For example if a preset resistance of '10' for a 'DOOR' is applied, and the airway has an underlying resistance of 0.015, then a total resistance of 10.015 will be applied during simulation.

The reversing resistance is an optional field which applies a different resistance should an airflow be reversed during simulation, and the 'restrict airflow direction' flag is chosen for the airway. Reversing resistances may be useful in situation where resistance increase (such as automatic doors closing, or flaps sealing) or where resistances decrease (such as doors swinging open automatically) when airflow direction changes. Such setups may occasionally be used to prevent recirculation or assist with emergency response design when fan direction may be reversed. If the value is left at zero (0), then a default reversing resistance (specified in the SETTINGS) will be applied if an airway is reversed AND the 'restrict airflow direction' flag is selected.

5.2.2 Friction

Up to 100 different frictions factor preset can be entered or used. The friction values in the EDIT box can be applied as presets (entered in the preset form) or as individual 'CUSTOM' values or as AUTO values which defaults to a value specified in the SETTINGS.

5.2.3 Shock

Shock equivalent lengths or shock factors can be entered in the shock preset area. The application of these factors will depend on which shock loss method is specified in the SETTINGS. The values for each shock item during simulation will be applied according to the method chosen. Only the value of the shock loss method used, needs to be entered.

5.2.4 Heat

Up to 250 different heat, moisture and refrigeration sources can be entered. Each 'Heat' source can be a combination of different heat parameters (such as moisture and sensible heat combined). Airways with a specified heat source will have these values applied during simulation. The screen also shows the number of heat sources currently in use.

5.2.5 Layer Prim, Layer Sec, Air Type

The form shows current names for these items, and in the case of layers, whether they are being used or not. The names can be changed at any time, however additional layers or air types cannot be added beyond what is already in the form.

5.2.6 Fans

Present a summary of current fans, and the basic characteristics of those fans (eg diameter, air density for the curve etc). While the fan curve data cannot be directly edited from this screen (you will need to go to the fan database), the fan names can be changed as well as the other fan parameters, or fans can also be fully deleted from the network. A read only column states the number of fans in use in the network.

Chapter

6

Chapter 6 SETTINGS

6.1 Airway Defaults

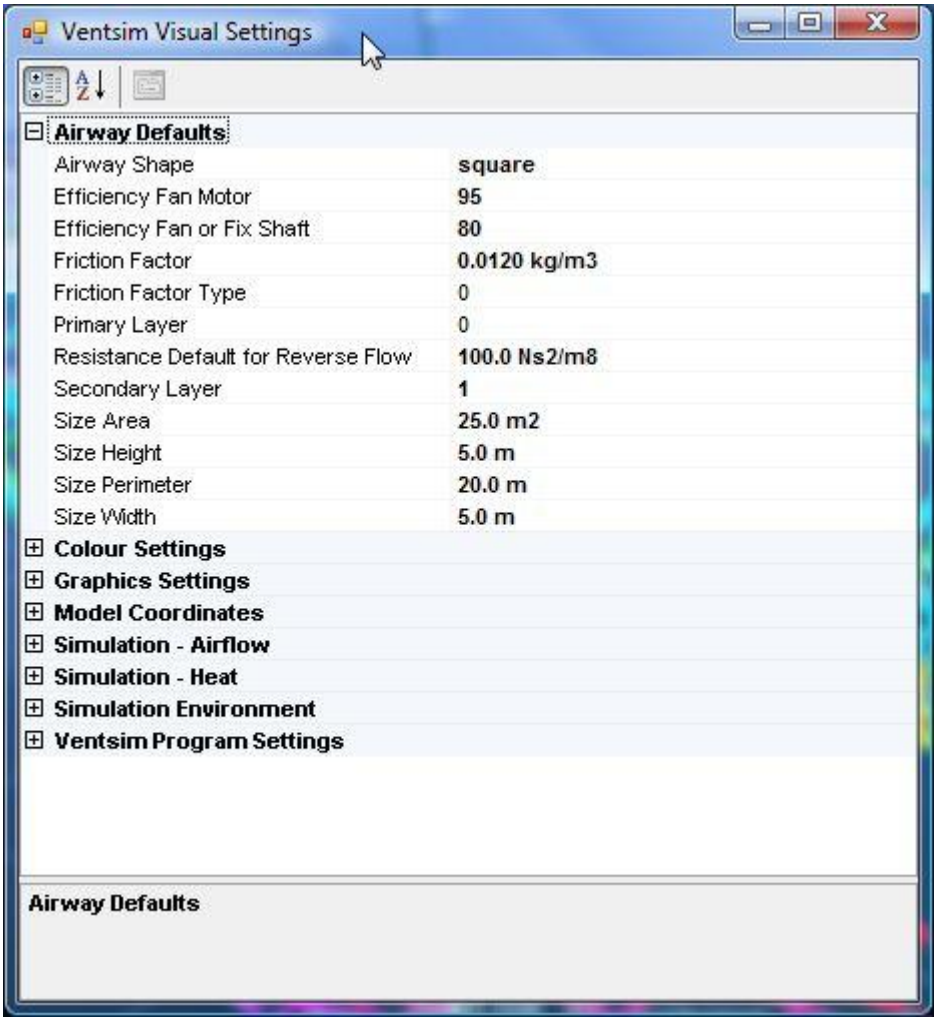


Figure 6-1 Airway Default Settings

Airway Shape **Default shape of airway**.

Efficiency Fan Motor: **Default fan motor efficiency** to apply to calculated fan shaft power to estimate the electrical power absorbed by the fan motor. In most cases it will be around 95% for direct drive electrical motors, or as low as 80 – 85% for offset or gear drive fans.

Efficiency Fan Fix: **Default efficiency factor** to apply to motor shaft power calculations for fixed quantities and fans without efficiency curves.

Friction Factor **Default friction (K) factor** to apply to new airways

Friction Factor Type The number of the friction factor type to use on a default airway

Primary Secondary Layer **Default view layers** to set to new airways.

Reversing Resistance **Default resistance** to apply if resistances are set in airways which have reversed airflow AND the 'restrict' reverse airflow button is pressure. This is only applied if no reversing resistance already exists for the preset item. For example a resistance for a door may be 10 during normal flow direction, but may reduce to 0.5 when the airflow is reversed and the door swings open. Once again, this figure is ONLY applied if the 'restrict reverse airflow' option is chosen in the EDIT box, AND there are no pre-existing reversing resistances set in the resistance preset spreadsheet.

Layers – Primary and Secondary **Default layers** to apply for new airways.

Size Width, Size Height, Size Area **Default size of new airways**. Imported DXF and text files without specific airway size will also be set to these values

Hint : Airway defaults are normally only applied if airways are constructed without connection to other airways. Where airways are connected to existing airways, they will INHERIT the settings of the airways the new airways is connected to. This behaviour can be modified from the EDIT > NEW AIRWAYS menu item.

6.2 Colour Settings

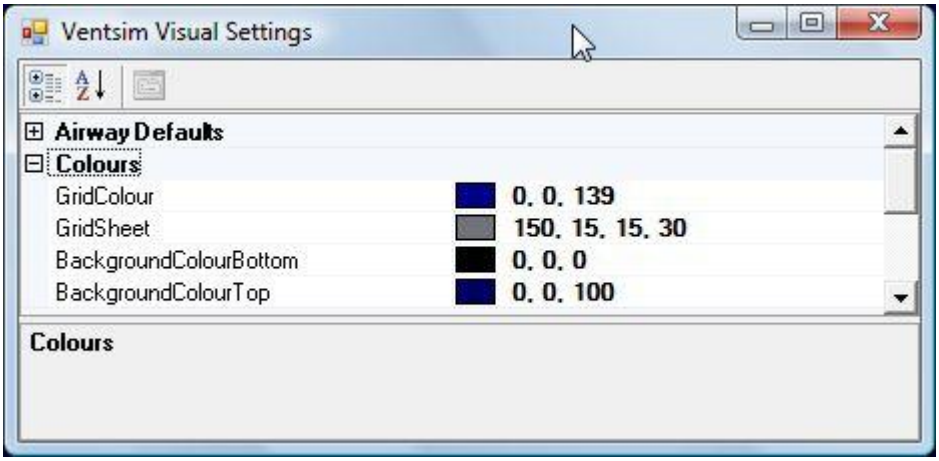


Figure 6-2 Colour Setting Options

Grid Colour **Colour of grid lines.**

Grid Sheet **Colour of semi-transparent edit plane** sheet shown during vertical drawing operations.

Background Colour Colour of upper and lower halves of background. The colours are smoothly blended to provide a gradient effect. Lighter colours may be more appropriate for presentations and report.

Colour Text Data Colour of the airway data. Text colours may need to be adjusted to provide contrast if the background colours are adjusted.

Colour Text Airway Colour of the airway text names and error messages. Text colours may need to be adjusted to provide contrast if the background colours are adjusted.

Colour Text Node Colour of the airway node names. Text colours may need to be adjusted to provide contrast if the background colours are adjusted.

6.3 Graphics

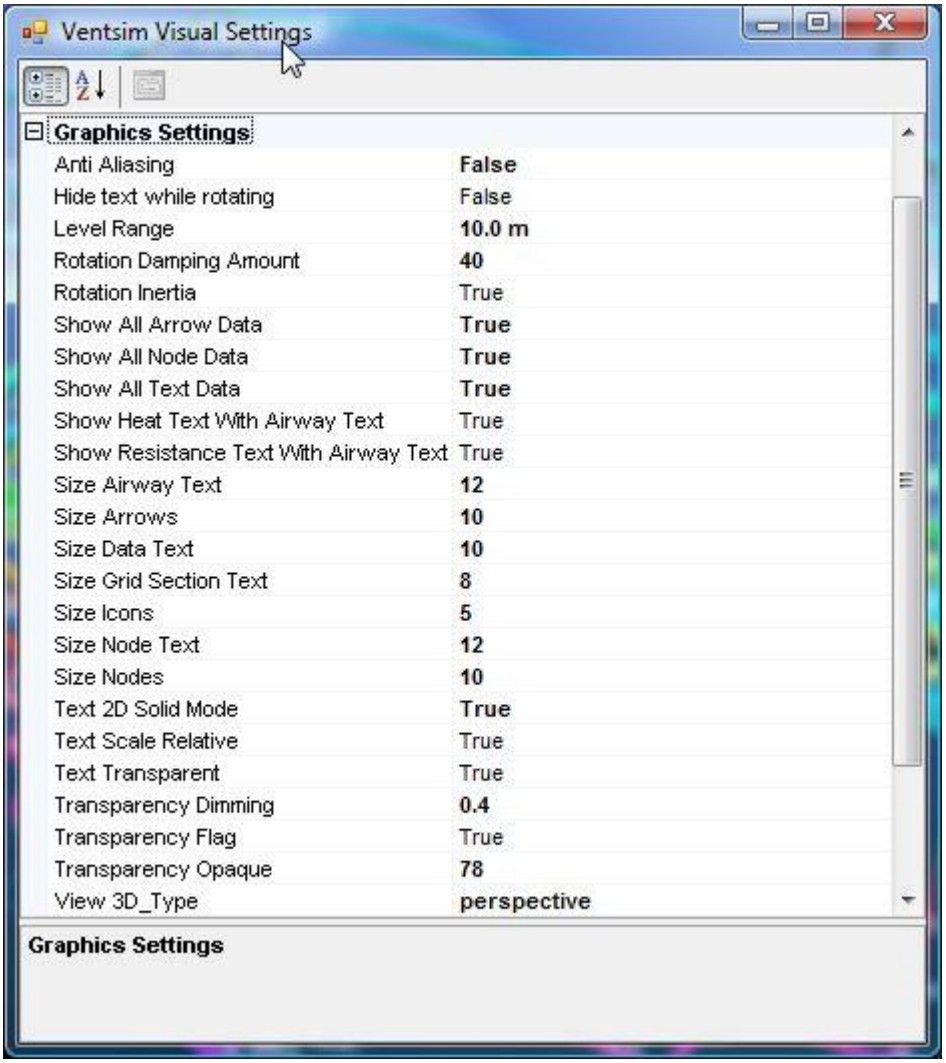


Figure 6-3 Graphics Setting Options

Anti-aliasing **An advanced graphics option** (not supported by all graphics card) which smooths the appearance of the edges of solids to give a visually more appealing look. The option may significantly slow some graphics cards or cause graphics irregularities. By default, it is set to FALSE.

Figure 6-4 Graphics Setting Options

Hide Text While Rotating **Hides text while model is rotated or zoomed**. Very large models with lots of text can slow or make smooth rotation movements unresponsive. Use this option to hide text and make rotation movement much smoother.

Level Range **The range of elevation to show around a single selected level**. Selected levels may be chosen from the RIGHT CLICK mouse popup menu, and limit the range of airways data shown on screen.

Rotation Inertia / Damping Ventsim model rotation results in a short period of continued rotation after the mouse is released. This is purely for visual appeal and is provided to give models the illusion of 'weight' and solidity. The speed at which rotation is damped can be adjusted or turned off using these settings.

HINT To allow the model to rotate freely without stopping, choose a damping level of zero (0).

Show All Arrow/ Node/ Text data. Hide or shows arrow, node and text data by default. This can be used to improve display clarity by removing unnecessary graphical details. Note that this function can be overridden from the View menu options or the RIGHT click context menu options for text and other graphical items.

Show Heat Text with Airway Text Shows the thermodynamic setting names on the airways they are attached to.

Size Data Node Airway Text **Size of airway text displayed on model**. Larger text sizes are generally clearer to read, however excessive data may clutter display.

Size Node Icons/Arrows **The size of the nodes, icons and arrows**. Note that the size reduces in wireframe mode to improve display legibility. In Solid mode, Icons and Nodes will not be reduced smaller than the airway size.

Text2DSolidMode Text display defaults to a pseudo 3D mode which show text as horizontal labels which move dynamically with airway positions. Setting to *False* presents a different method of displaying airway data on branches. Data is imprinted into the airway sidewall and rotated and scaled with the airway model. In some circumstances it may or may not improve legibility.

Text Transparent The background for text characters is shown as a solid colour, or transparent. Turning off text transparency can improve clarity of text graphics, but will obscure the airway graphics behind the text.

Transparency Flag **[TRUE]** Completely hides airways outside the display range.

[FALSE] Airways outside the display range are shown as semi-transparent. The level of transparency can be adjusted from the Colour Manager.

Note that this function setting has largely been made obsolete by the VIEW > TRANSPARENCY menu function which can define a number of different transparency options for different types of data.

Transparency Opaque **The default level of transparency for transparent airways**. This can be adjusted in the Colour Manager

Transparency Dimming **The relative colour of transparent airways**. Lower value will make transparent airways darker.

Size Node Icons Arrows **The size of the nodes, icons and arrows.** Note that the size reduces in wireframe mode to improve display legibility.

Text Transparent **[TRUE]** Text labels backgrounds are transparent and show graphics under the label.

[FALSE] Text label backgrounds are solid and do not show graphics underneath. In some cases, this may improve the legibility of text.

Text Scale Relative **[TRUE]** Reduces the size of text labels relative to distance away from view camera. This make close airways larger and more legible and distant airway text smaller.

View3D_Type Sets the viewing system to orthogonal or perspective. Orthogonal removes the effect of perspective, making objects in the distance appear the same size as close objects. This mode may be of assistance when viewing sections or plan views, where the perspective appearance would otherwise distorted the true scale of objects at different distances. The mode has the disadvantage of a more cluttered and complex display.
Perspective view is more suited to general editing and viewing, where objects in the distance are obscured by perspective scale, creating a less cluttered display.

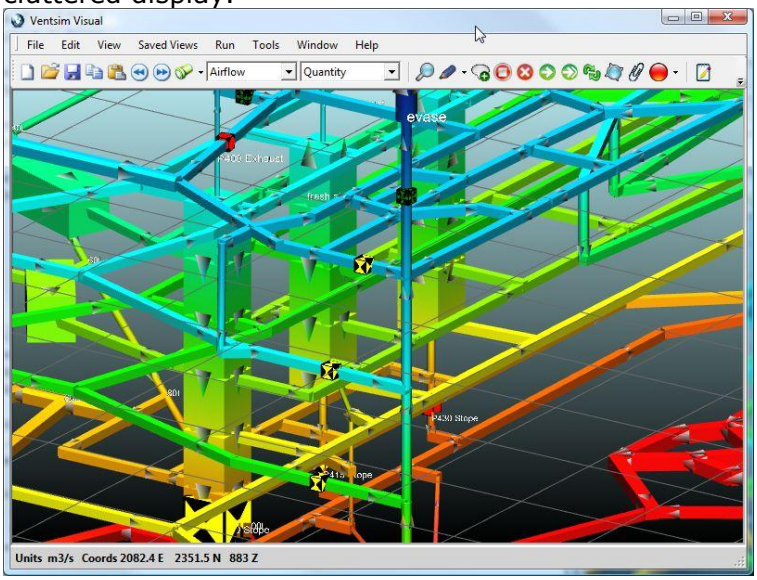


Figure 6-5 Orthogonal Display

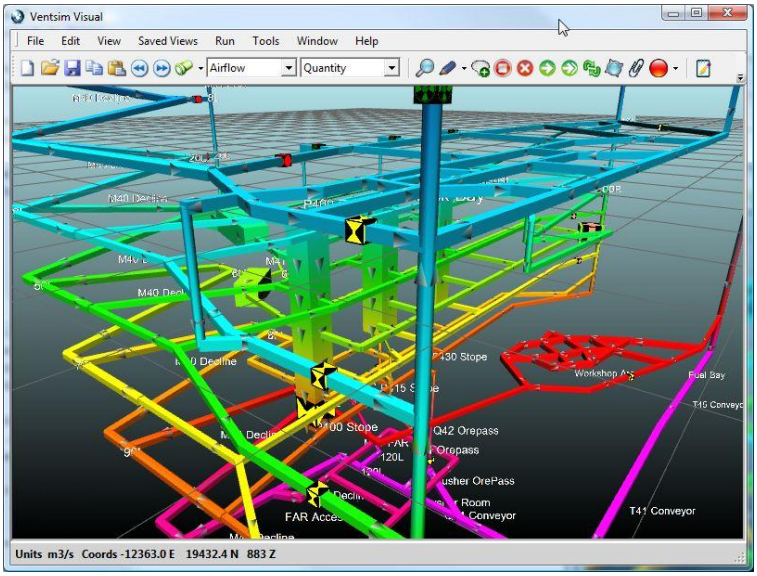


Figure 6-6 Perspective Display

Hint : When performing true PLAN or SECTION views, ensure that ORTHOGONAL mode is chosen to prevent perspective errors in these views. In plan or section view, airways at a different plan or section depth will be shown at a different scale in perspective view. You can quickly change between views by pressing the 'P' key on the keyboard.

6.4 Simulation – Airflow

Simulation airflow settings directly influence how the airflow simulation operates.

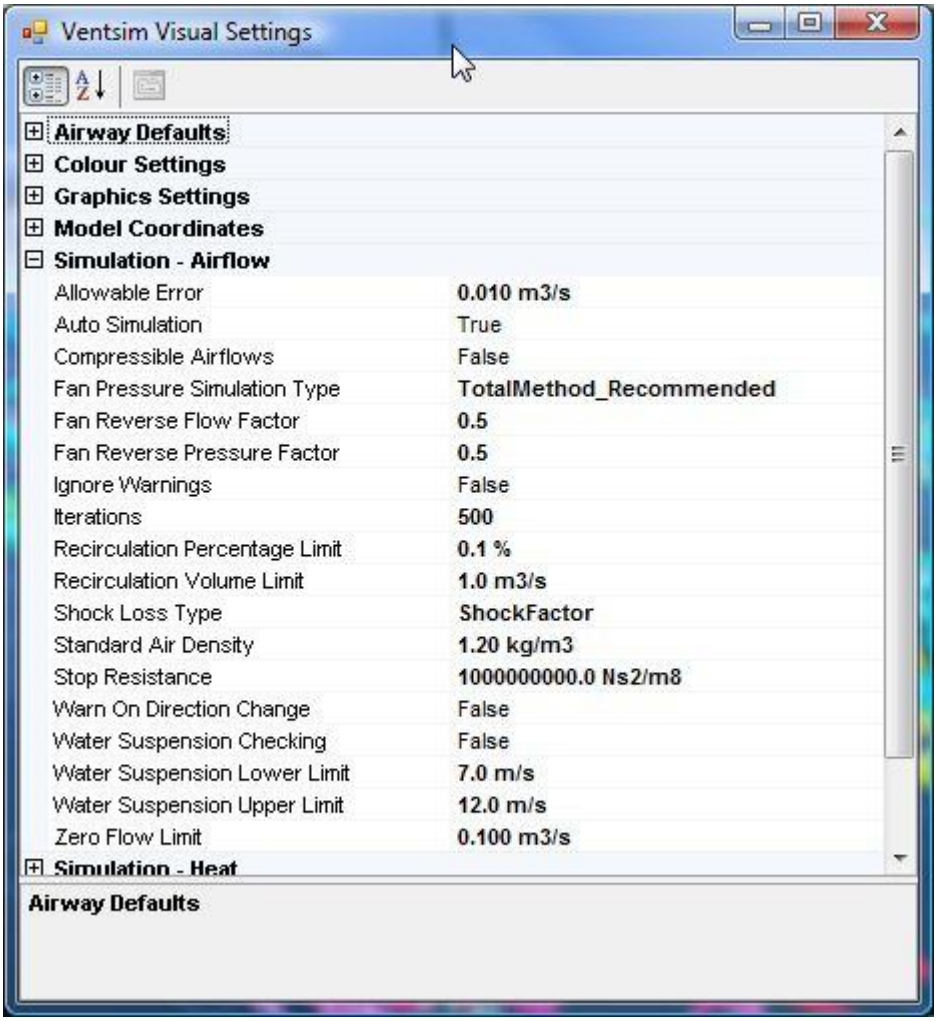


Figure 6-7 Ventsim Visual™ Settings

Allowable error **Defines the level of accuracy** Ventsim must resolve down to before an acceptable solution is displayed. This should normally be set to less than 0.1 m3/s error. If a final analysis is required it may be advisable to set this to 0.01 m3/s or lower. The smaller the value, the more accurate the simulation process, but the longer it may take.

Auto simulation **Automatically performs an airflow simulation** after every modification to a network. This will conveniently display airflow amounts and directions without having to simulate the network. For large networks, or networks undergoing extensive modifications, it may be preferable to turn this function off, as it will slow down editing and view functions.

Compressible Airflows {Advanced] **Use compressible airflow simulation techniques.**

Compressible airflow has a significant influence when simulating deeper mines. In deeper mines (greater than 500m) or when heat simulation is used, it is recommended that compressible airflow be set to **True**.

When set to **True**, Ventsim Visual™ will assume compressible air, and adjust air densities, volumes and fan curves according to airway depth and corresponding density. In the ***Advanced*** version, temperature effects on density are also taken into account when *Heat* simulation is *run* in conjunction with air simulation.

Airflows and fan curve performance after simulation is shown according to the density of air at the location of the airway.

Density Adjust Friction Factors

Enables the simulation to adjust the friction factors to the local airway density. As resistance is a factor of friction, this will in turn adjust the airway resistance value. This setting is set to YES by default.

When set to YES, all preset friction factors are assumed to be specified at a standard density of 1.2kg/m3. If compressible airflows are enabled, the factor will be adjusted to the simulated local air density, otherwise the factor is adjusted to the standard environment density setting.

If this setting is not enabled or the airway EDIT form has set the value to 'Already Adjusted', then the actual value entered in the preset will not be adjusted.

Density Adjust Resistance Factors

Enables the simulation to adjust the preset resistance values to the local airway density. Preset resistance values do not use friction factors, therefore any friction factor setting is ignored.

When set to YES, all preset resistances are assumed to be specified at a standard density of 1.2kg/m3 and will be adjusted to suit the local airway conditions. If compressible airflows are enabled, the preset value will be adjusted to the simulated local air density, otherwise the value is adjusted to the standard environment density setting.

If this setting is not enabled or the airway EDIT form has set the value to 'Already Adjusted', then the actual value entered in the preset will be used.

HINT : Density adjusted friction and resistance values are a potential source of confusion. Most text books will quote friction and resistance values standardized to a 1.2kg/m3 air density. If standard values are used, ENSURE that both of the Density Adjust options are set to YES

If resistance or friction values are measured locally however, then the values obtained are only valid for the density at which they are measured. To use measured values in Ventsim, you will need to consider one of the following options.

OPTION 1 : If all preset values are measure at the true mine density and will not be used or duplicated elsewhere in the mine, then simply turn off the density adjust setting for resistance and/or friction values.

OPTION 2 : If only some values are measured and other values are standardized to 1.2kg/m3, then you will need to use the EDIT form setting to set individual airways to 'Already Adjusted" (the check box next to the resistance or friction value)

OPTION 3 : To avoid the potential confusion of Option 2, you may want to simply convert all of your measured values (at the local mine density) to a 1.2kg/m3 standard and set both settings to YES. This also has the benefit of allowing the setting to be used elsewhere in the mine at different densities.

Fan Pressure Simulation Type

Specifies the fan pressure simulation method to use. Ventsim has historically allowed use of a combination of static and total pressures to simulate air flow through underground and surface fans. To maintain compatibility, this option has been kept, however two alternative methods are presented.

Total Pressure Method

The use of fan total pressures is considered the technically correct method for simulating airflows. All fan curves in the fan database must at least have a total pressure component. If only a fan static pressure curve is available an error will be raised during simulation. Ventsim Visual™ can help predict a fan total pressure curve from an existing static pressure curve using tools in the Fan Database Editor.

The total pressure method assumes the full fan total pressure is available to 'push or pull' air through a mine. The method also considers system velocity pressure losses to the atmosphere (for example from exhaust shafts) and incorporates these into the simulation. The fan total pressure method relies on the user accurately considering fan exit losses with appropriate shock loss factors and resistances, as total fan pressure is rarely fully available to deliver pressure to network air flow. Fan outlet configuration, outlet flow direction changes and the inclusion of evasé s (which boost static performance and reduce exit shock losses) or other exit devices such as fan shutters need to be fully considered if they have not been incorporated into the fan curve, otherwise the network may over predict the available pressure and flow.

Static Pressure Method

A more traditional approach is to use fan static pressure, which assumes that fan velocity pressure is wasted and does not contribute to the system ventilation pressure and flow. While this is not technically correct, this assumption removes some of the criticality of defining accurate exit losses, and while exit losses should still not be ignored, the resulting simulation will provide a more conservative result to simulation estimates of pressure and flow. The Fan Static Pressure (FSP) method also ignores system exit velocity pressure losses. For a primary (surface) fan driven network systems, there is negligible difference between the FSP and FTP methods (as the FTP methods considers velocity pressure losses as part of the system pressure), however where underground booster fans contribute to a significant portion of ventilation flow, the difference between the two methods will increase.

To use this method, all fan curves used from the database must have a static pressure component. If only a total curve is available an error will be raised during simulation. As with the FTP method, the fan database form has tools to assist the user in estimating FSP curves if not available.

Mixed Pressure Method

The mixed pressure method maintains compatibility with Ventsim Classic 3.9, which allows both pressure types (static and total) to be used for fans in networks. The mixed pressure method is similar to the static method, in that it does not considerer system velocity pressure exit losses. Fan pressure curve types can be specified for each fan location in the network. This may be of

assistance if some static or total pressure curves are not available for the fan, and the user does not wish to estimate a curve. The mixed pressure method is considered to be the least consistent method to use, and should be avoided if possible. In particular, the use of fan total pressures for surface exhaust fans will overestimate the performance in a network as the system velocity pressure losses will not be considered

> Ventsim Classic 3.9 networks will be automatically imported into Ventsim Visual™ as a 'mixed pressure network'. It is recommended for consistency, the network be either set to a StaticMethod network or a TotalMethod network. Some fan curves may need to be modified to allow this to be done.

Fan Reverse PFactor, Fan Reverse QFactor **Defines the default reverse fan performance** relative to the original fan curve for the pressure and quantity of a fan running in reverse. These factors decrease the performance of fans set to run in reverse (for emergencies for example) in the EDIT box. Note that the default values may be overridden by values directly placed in the Fan Database for individual fans.

Ignore Warnings **[TRUE]** Ventsim Visual™ will ignore all warnings related to No *Entry or No Exit* errors found during simulation (airways with no other airways joining)

[FALSE] Ventsim Visual™ will only ignore airways which have been set to *Allow Open End* in the ***Edit*** box. Any other 'orphaned' airways will cause the simulation to halt.

Iterations Sets the number of attempts Ventsim Visual™ can take to achieve an acceptable error, before the program abandons the simulation process.

Recirculation Limit Percentage [Advanced] The percentage of air that is allowed to recirculate before the Check Recirculation routine flags a warning

Recirculation Limit Volume [Advanced] The volume of air that is allowed to recirculate before the Check Recirculation routine flags a warning. Both the recirculation percentage and the recirculation limit work cooperatively, with both conditions needing to be exceeded before a warning is raised.

Shock Loss Type **Defines the shock loss method to use.** Ventsim Visual™ can be set to calculate shock losses using the equivalent length method, or the shock factor (X) method. Shock loss calculations are necessary to estimate pressure loss due to air turbulence cause by a change in airway direction, a junction or a change in airway size. Note that changing this value in an existing network will result in Ventsim Visual™ requesting to recalculate the shock losses using the alternative system.

The equivalent length method requires the user to estimate an equivalent extra airway length required to approximate pressure loss due to shock. The shock factor (X) method uses a calculated factor derived from both empirical and calculated changes in airway areas and velocities. Both methods are described in any number of ventilation texts.

Once the method is set, the Edit Box will require an appropriate shock loss value for each airway. The Edit Box can accept a manually entered number, but also has a number of preset values, as well as an AUTO function which will force

Ventsim Visual™ to attempt to calculate a shock loss factor or an equivalent. length.

Standard Air Density The standard air density used for simulation of airflow, where compressible airflows are not set, or Ventsim Visual Standard is used. The air density is uniformly applied throughout the mine, and all pressure and heat calculations are referenced back to this standard value. Note that this value is ignored when compressible airflows have been selected.

Stop Resistance **Defines the minimum resistance** at which Ventsim Visual will completely stop all airflow in an airway. All preset resistances above this value will cause airflow in the set airway to completely stop. No more than one Preset Resistance value should be greater than the Stop Resistance value. This function artificially restricts airflow and has the potential to cause simulation problems if used on too many airways. The simulation will check and ensure that only one (or nil) preset resistances are greater than this value.

Warn On Change Direction If set to TRUE, Ventsim Visual™ compares airway directions before and after a simulation and alerts the user which airways have airflow that have changed direction during simulation.

Water Suspension Checking If set to TRUE, Ventsim Visual™ will perform a check on all up casting vertical or semi vertical (>45 degrees) airways. The water suspension phenomena occurs on water droplets where the up casting air velocity friction is counteracted by gravitational forces, forming a suspended column of water droplets which can greatly increased shaft resistance and pressure. This can only be overcome by reducing airflow velocity allowing water to fall to the shaft bottom, or increasing velocity to carry the water out of the top of the shaft. The exact critical velocity depends on shaft size and geometry, as well as water droplet size and geometry of entry into the shaft.

Water Suspension Upper and Lower Velocity The upper and lower limits at which Ventsim Visual will flag a warning if water suspension checking is optioned. Warnings do not affect simulation, but simply alert users to potential problem areas.

Zero Flow Limit The flow at which Ventsim Visual assumes 'zero' flow. This function does not directly affect simulation, and is simply used to determine whether airways are displayed when the 'zero flow' graphical option is used to hide airways with no flow.

6.5 Simulation – Heat [ADVANCED]

Adjusts settings which directly influence how the heat simulation operates.

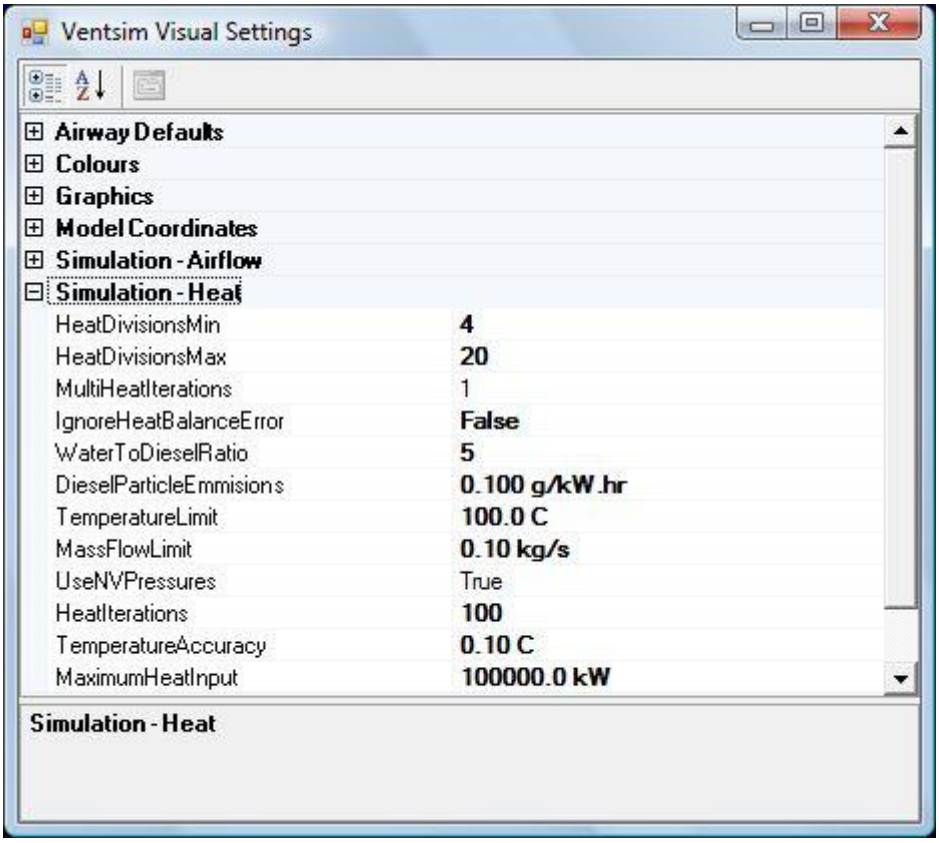


Figure 6-8 Simulation Heat Settings

Heat Divisions Min/Max **Airway segment divisions for heat calculations.**

The heat simulation process in Ventsim Visual™ progressively calculates heat affects along each airway by dividing it into sections. When a rapid change takes place or where the airway is very long, this allows the psychrometric process to continually adjust pressures, temperatures and moisture content, resulting in a more accurate estimate. Ventsim Visual™ automatically adjusts the number of divisions according to airway length and heat inputs. The number of divisions used is restricted by the **min** and **max** values in the settings. Higher division values will theoretically give more accurate heat estimates but will increase the time required for simulation.

Multi Heat Iterations **Performs multiple airflow and heat simulations.**

When set to more than one (1) performs multiple heat and airflow simulations, adjusting densities and airflows between each simulation. Manually pressing the HEAT simulation button has the same effect.

Heat simulation in Ventsim Visual™ Advanced is performed as two discrete simulations, first as an airflow balance, followed by a heat balance simulation. While the mass flow balance from the airflow simulation is kept constant during heat simulation, the new temperatures and air densities calculated after heat simulation, result in a theoretical mass imbalance of airflows. This can be corrected by a subsequent airflow simulation; however subsequent heat

simulations will again affect the balance. This imbalance normally reduces with subsequent simulations, as temperatures and airflow changes reach equilibrium.

Multiple pass iterations can be set which will automatically force Ventsim Visual™ to simulate the network a number of times, to account for some of the potential imbalance. This will significantly slow down simulation time. Iteration values larger than one are usually unnecessary if a network has already been heat balanced, or if the HEAT simulation button has already been pressed a number of times.

HINT Performing a multiple pass heat simulation may have value if the network shows some heat instability (changes in temperatures between simulations). Heat instability is often caused by unstable natural ventilation changes driven by conflicting changes in airflow, strata heat and evaporation.

For example a heat source which causes an increase in temperature may cause an increase in airflow due to natural ventilation – in subsequent simulations, the higher airflow causes lesser temperature increase from the heat source, which in turn reduces the airflow due to natural ventilation. Evaporation from strata moisture may also causing conflicting density changes, with strata heat density changes offset by cooling evaporation. The process may then oscillate between solutions for each heat simulation. As a final pass performing a multiple pass simulation of 10 or 20 (which may take a long time) may help resolve this instability.

Ignore Heat Balance Errors

Extreme changes in airflow temperatures along airways or at junctions may create difficulties for Ventsim Visual™ to calculate the new psychrometric properties in an acceptable number of iterations. Normally the error is small and may be resolved during the simulation process as surrounding airways are adjusted, and the degree of change is reduced in subsequent iterations.

Setting this value to TRUE allows the simulation process to ignore imbalances and continue towards an acceptable solution.

CAUTION: Allowing heat balance errors to be ignored may propagate an extreme heat balance error along other airways. This will normally result in the simulation process halting due to other heat related errors (such as over-temperature). For this reason, unless there are continued heat balance issues, it is recommended this normally be left as FALSE unless all other options to resolve a poorly simulating network are explored first.

Water to Diesel Ratio

For diesel heat sources, **this value defines the amount of water emitted to the air as latent heat** is per unit weight of diesel fuel consumed. Although the theoretical combustion reaction portion of water produced to fuel consumed is only around 1.1, the operation of a diesel machine in a mine environment results in a greater release of water into the air due to accelerated evaporation of water around the machine (from a wet roadway or walls for example), compounded by other sources such as handling of moist or wet material, wet exhaust scrubbers and cooling systems used by the machine, result in a much higher value. A value of five (5) or more is generally recognised as giving a more realistic result for water introduced to the air by mobile machines. Stationary machines may be closer to the theoretical value.

The default water to diesel ratio is used on all diesel sources in the network. To use values other than default, the sensible and latent heat will need to be entered separately instead of a single diesel heat source.

Diesel Particle Emissions **Describes the default amount of diesel particles emitted from a diesel engine, per unit of diesel engine power**. This value is applied to diesel heat sources placed in a network, to assist in diesel particulate matter (DPM) simulation for the model. The value is highly dependent on the type of diesel engines, catalytic converters and scrubbers being used on the exhaust, as well as the type of diesel fuel used. In most cases, tests will need to be done on engine exhausts, or information gained from diesel engine manufacturers to find the correct value to use. Ventsim Visual™ will apply this default value to diesel sources which have not been assigned a specific emission rate. Specific rates for diesel equipment and airways that will override this default value can be assigned in the Presets or in the Edit box.

Temperature Limit **The temperature limit above which Ventsim Visual™ will halt simulation and display an error if it occurs**. Temperature limits can be exceeded when too higher heat input is placed in an airway with not enough airflow.

Heat simulation uses a number of empirical formulas which are designed to work within a specific temperature range. In general, temperatures above 70 degrees centigrade will start to result in a reduction of accuracy of heat estimation.

Mass Flow Limit **The minimum mass flow that Ventsim Visual™ will perform a heat simulation on**. Below this limit, Ventsim will assume the air is stationary, and adopt the local virgin rock temperatures as the air temperature. This value must be set above zero, as portions of the program which calculate heat and moisture derived from rock surfaces must have some airflow velocity to work. While there is some potential for heat imbalance errors by not taking into account low flow airways, it is generally small due to the limited heat energy flow able to be carried by these low flow airways.

Use NV Pressures **[TRUE]** Forces Ventsim to calculate natural ventilation pressures derived from air heat and density in the underground network. Natural ventilation pressures can sometimes produce unstable simulation air flows due to dynamic changes in airflow affecting subsequent heat balance simulations. This is discussed further in the *Heat Simulation* section. If this problem impacts heat simulation, providing natural ventilation pressures are not critical, it is suggested to set to it to *False* to produce a stable simulation.

[FALSE] Ignore natural ventilation pressures. Where heat simulation is not required, or natural ventilation pressures are not likely to be significant in a mine, it is suggested that this setting be set to FALSE.

Heat Iterations **Limits the number of internal iterations** permitted by Ventsim Visual™ to converge and find an acceptably balanced heat solution. Where recirculation occurs or large numbers of very low airflows are present, a simulation may take a large number of iterations to fully balance. In most cases, the main airflows will quickly balance, and even if the simulation fails to complete within the set number of iterations, this will usually be in the low flow airways which have little effect on the main flow airways. The status bar at the base of the Ventsim Visual™ window will show the progress of a heat simulation, including the number of iterations and the heat balance errors. Increasing the number of iterations may help resolved unbalanced networks, but will take longer to simulate.

HINT A leading cause of heat flow convergence issues is recirculating airways in low flow airways due to natural ventilation pressures. Natural ventilation pressures can create internal 'eddies' of air in disused or low flow airways which can affect heat

simulation convergence. To prevent this, and speed up heat simulation, either turn off natural ventilation simulation (if natural vent pressures are not significant) or block disused airways so they simulate as no flow.

Temperature Accuracy **Sets the temperature balance limit** Ventsim Visual™ must achieve for all airway mixing at junctions in a network, to consider a simulation as balanced. If the balance is not achieved for EVERY airway and junction, iteration is performed until the iteration limit is reached or temperatures are resolved.

HINT The smaller the temperature accuracy set, the longer a simulation may take to complete. In most cases, the vast majority of airways will fall well under this limit, and any temperature accuracy issues will be limited by very low flowing airways which have little impact on the main network.

Maximum Heat Input **Limits the amount of heat** that can be put into a single airway. This is mainly included as a check to ensure excessive heat is not placed in an airway (such as a point heat source value accidently being entered as a linear heat value).

6.5.2 Simulation Environments [ADVANCED]

The environment factors describe values used by physical items within the network. They are critical to identify the base starting points of a ventilation simulation, or providing default air or heat simulation parameters to airways that do not have specific values set.

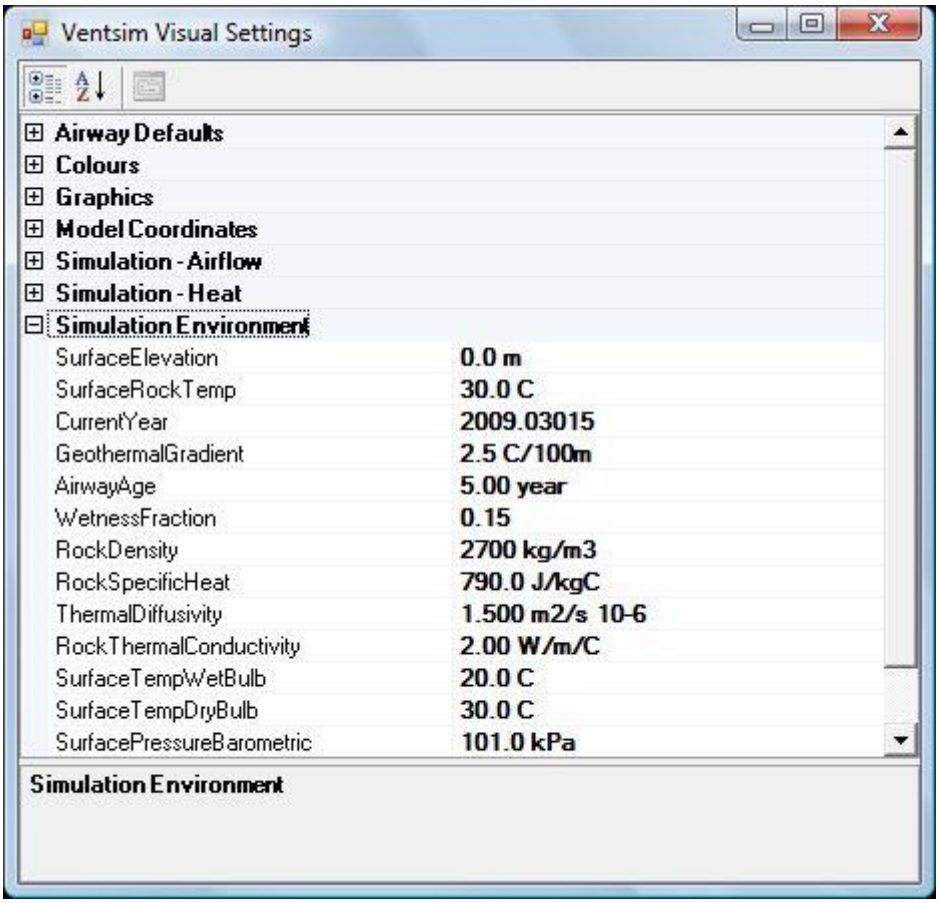


Figure 6-9 Simulation Environment Settings

Surface Elevation **The elevation (or 'reduced level') where a specified point in the mine exits the surface**. All other surface related settings (such as surface temperatures, pressures and rock temperatures) are assumed to be at this elevation.

If this value is set to zero (0), Ventsim will search and use the highest point in the network.

Surface Rock Temp **The temperature of virgin rock at the Surface Elevation.** Virgin rock temperatures underground are calculated from this base by using the Geothermal Gradient.

Current Year **The calendar year at which the simulation is taking place.**

Ventsim Visual™ uses this value to calculate the age of an airway underground, if the individual airway age is entered as a calendar year (such as '2005' in the EDIT box). Where an airway age is entered as a time value (such as '3.5' years), the CurrentYear value is ignored.

HINT Where true airway ages have been entered as calendar years within a network, the CurrentYear setting is useful for 'ageing' a mine and determining future cooling requirements. Heat input or 'flux' from virgin rock strata decreases exponentially over time as the rock is cooled, and future cooling requirements can potentially be lower than current cooling requirements as a result.

Geothermal Gradient **The rate at which rock increases in temperature at depth**. This is assumed to be a linear value. Geothermal gradients show significant differences at different points around the earth, and can be as low as 1 degree Celsius per 100m to more than 10 degrees Celsius per 100m. This value should always be adjusted to suit the conditions at or near your mine.

HINT In rare cases, the temperature gradient may not be close to linear, particularly in near surface portions of the mine. The best approach is to calculate to gradient over the main underground portion of the underground mine (which a subject to the majority of heat influence), and project this temperature gradient to the surface. Enter the 'SurfaceRockTemp' settings as this calculated value, not the true surface rock temperature.

Orebody Type	Degrees C/100m		Degrees F/100ft	
	Min	Max	Min	Max
Copper Ore body	2.5	7.7	1.4	4.2
Carboniferous	2.0	5.0	1.1	2.7
Clays	3.3	3.3	1.8	1.8
Limestone	1.8	1.8	1.0	1.0
Sandstone	1.7	3.3	0.9	1.8
Dolerite	3.0	3.0	1.7	1.7
Quartzite	0.8	1.5	0.5	0.8
Potash Low Grade	1.3	1.7	0.7	0.9

Potash High Grade	0.8	1.3	0.5	0.7
Halite Low Grade	1.4	4.0	0.8	2.2
Halite High Grade	1.0	1.4	0.5	0.8

Table 6-1 Examples of Geothermal Gradients found in areas around the world

Average Age **The Default Age of an airway opening in years**. Airways without a specified age set in the ***Edit Box***, will be assigned this airway age. Establishing airway age is important to all Ventsim Visual™ to calculate heat flow into an airway from geothermal heat. Geothermal heat flow decreases with airway opening age.

Wetness Fraction **The default fraction of airway rock surface that is wet**. Nearly all rock surfaces underground emit some degree of moisture. The wetness fraction defines what percentage of rock surface is considered wet. A value of 0.01 would define a very dry airway, while a value of 1.0 would define a fully wet airway. This value will be assigned to airways without a set wetness fraction from the ***Edit Box***, and directly affects the amount of moisture available for airflow to evaporate and hence humidify the air.

Rock Density **The default density of rock underground**. This value is applied to an airway, if it has not already been set in the Edit Box. Rock density is a property which describes the mass of rock per unit volume. Rock density underground is used by Ventsim to calculate the directly related thermal diffusivity of rock material, if the diffusivity has not already been yet. Rock Density is not required if thermal diffusivity has already been set. If this value is changed, the user will be prompted to allow Ventsim to auto calculate the rock diffusivity.

Rock Specific Heat **The default Specific Heat of rock underground**. This value is applied to an airway, if it has not already been set in the Edit Box. Rock Specific heat describes how much heat must be absorbed or emitted to raise or lower the rock temperature.

Thermal Diffusivity **The default Thermal Diffusivity of rock underground**. This value is applied to an airway, if it has not already been set in the Edit Box. Rock Thermal Diffusivity is a property which describes the ability of rock to diffuse or transmit contained heat over a unit area per unit of time. In summary, rock with high thermal diffusivity more rapidly adjusts its temperature to that of the surroundings, because it conducts heat quickly in comparison to its heat capacity or 'thermal bulk'. Because diffusivity is directly related to density, thermal conductivity and specific heat by formula, rock ***thermal diffusivity*** is required when underground rock density has not been set. If this value is changed, the user will be prompted to allow Ventsim to auto calculate the rock density.

Rock Thermal Conductivity **The default Rock Thermal Conductivity.**. This value is applied to an airway, if it has not already been set in the Edit Box. Rock Thermal Conductivity is a property of rock which describes the ability of rock to transmit heat through itself.

Surface Wetbulb Drybulb **The Default Surface Temperature Conditions of air entering a mine.** All air intakes into the mine are assigned the default surface temperatures. The temperatures and Surface Barometric Pressure are used to calculate the surface air density.

HINT: In rare cases, a mine may have multiple intake airways with a range of elevations so great that different temperatures may be present at each intake. As the Surface Barometric pressure is defined for a single Surface Elevation, Barometric Pressures will be correctly recalculated for differing intake elevations; however temperatures may need to be manually corrected. Temperatures can be adjusted by place a heat or cooling source at the inlet of intakes to produce differing temperatures.

Surface Pressure Barometric

The Barometric Air Pressure at the Surface Elevation.. The surface barometric pressure is important as Ventsim Visual™ calculates mine air densities from the surface barometric pressure and wet and dry bulb temperatures.

6.5.3 Examples of Rock Properties

Rock Type	Thermal conductivity	Specific Heat	Thermal Diffusivity
	W/mC	J/kgC	m2/s 10-
basalt	1.80	840	0.74
coal	0.33	1300	0.20
dunite	4.30	820	1.64
gabbro	2.10	800	0.97
gneiss	2.90	800	1.29
granite	3.00	790	1.41
limestone	1.30	840	0.64
magnetite	4.41	600	2.10
marble	2.60	880	1.18
quartzite	5.25	800	2.43
quartzite	3.00	800	1.39
rock salt	4.48	880	2.04
sandstone	1.70	920	0.71
shale	1.23	850	0.55

Table 6-2 Metric Examples of Airway Rock Physical Parameters

Rock Type	Thermal conductivity	Specific Heat	Thermal Diffusivity
	Btu/h/ftF	Btu/lbF	ft2/h
basalt	1.04	0.20	0.029
coal	0.19	0.31	0.008
dunite	2.48	0.20	0.064
gabbro	1.21	0.19	0.038
gneiss	1.68	0.19	0.050
granite	1.73	0.19	0.055
limestone	0.75	0.20	0.025
magnetite	2.55	0.14	0.081
marble	1.50	0.21	0.046
quartzite	3.03	0.19	0.094
quartzite	1.73	0.19	0.054
rock salt	2.59	0.21	0.079
sandstone	0.98	0.22	0.028
shale	0.71	0.20	0.021

Table 6-3 Imperial Examples of Airway Rock Physical Parameters

Warning – These are examples only. Rock characteristics vary widely for different rock types and locations. Where possible, characteristics should be measured by laboratory analysis.

6.6 Ventsim Main

Ventsim Main settings control over-arching settings which influence all parts of the program.

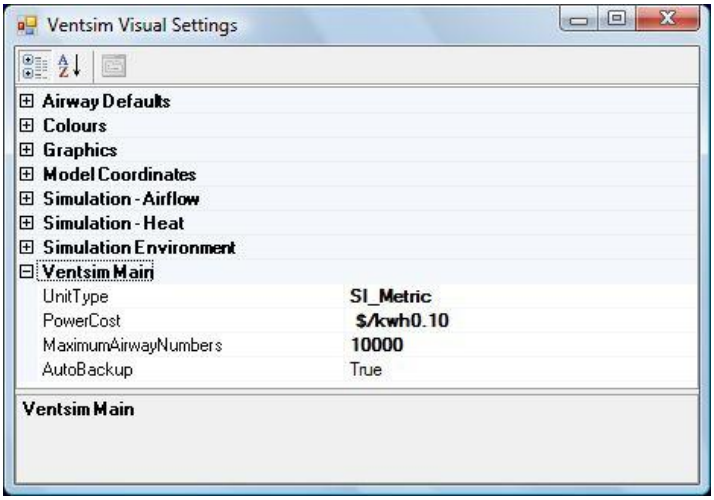


Figure 6-10 Ventsim Visual™ General Settings

Unit Type **The type of units to use in Ventsim Visual**. The program operates natively in SI Metric, with underlying calculations performed in metric units. To display imperial values and accept imperial input, set the unit type to *Imperial*. The imperial setting uses a conversion table to calculate the conversion from metric, and can be customised to suit mine preferences.

Warning – the conversion table has set limits of decimal accuracy to convert from metric to imperial and back again. If the decimal accuracy is too low, some accuracy may be lost in the conversion process, and the value input as an Imperial number, may be returned slightly differently.

Power Cost **The cost of power supplied to the mine**. The power cost is used to calculate the ventilation cost of running a mine network, and applied to all fans, fixed quantities and fixed pressures.

Maximum Airway Numbers **The amount of memory to reserve for airways and graphics.** Ventsim Visual™ reserves memory and resources for a defined number of airways. Reserving large numbers of airways will slow down graphics and simulation slightly. It is recommended to reserve only the number of airways actually required for the size of your network. If your network exceeds this number, Ventsim Visual™ will automatically adjust the setting to suit the higher number.

Auto Backup Forces Ventsim to make a backup of the currently worked network every 5 minutes. If the program crashes, or is forcibly exited, the backed up network will be loaded automatically next time the program is run.

Warning – if the network has become corrupted for some reason, there is a possibility that the auto-saved network may also be corrupted. For this reason, it is recommended that a network be regularly saved to ensure that good working copies are available as backups if required.

6.6.2 Auto Simulate When Loading

Two options are available to automatically simulate networks when they are loaded. Some ventilation simulation variables including some values shown in the network summary box are only temporarily calculated after a simulation and will be lost when the program is closed. To force the program to perform an airflow or heat simulation, the following options are

available. Note that if both an airflow AND a heat simulation is required, only the ***Simulate Heat On Load*** option needs to be selected. The features are not recommended for very large files (due to the time it takes for a simulation) or for files that are not fully balanced or working yet.

Simulate Airflow On Load Automatically performs an airflow simulation when the file is loaded. This will update simulation summary parameters and a number of calculated parameters only available after a simulation

Simulate Heat On Load Automatically performs an heat simulation when the file is loaded. This will update heat simulation summary parameters and a number of calculated heat parameters only available after a simulation

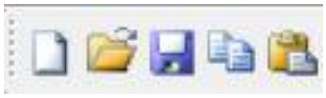
Chapter 7

Chapter 7 THE TOOLBAR

The toolbar allows quick access to commonly used Ventsim Visual™ functions.

The toolbar will be slightly different between Ventsim Viewer, Standard and Advanced versions.

7.1 File Input and Output Functions



7.1.1 New File

Creates a new file. The current file will be cleared.

7.1.2 Open File

Open the file dialog to load a new file

7.1.3 Save File

Saves the existing file. If no name has yet been set, a Save File dialog will be displayed.

7.1.4 Copy

Copies selected airways onto the Windows clipboard. The airway can then be pasted into a different network.

7.1.5 Paste

Pastes the airways in the Windows clipboard, back into the currently loaded network. Note that multiple instances of Ventsim Visual™ can be loaded, and the airways can be pasted into another instance of Ventsim Visual.

7.2 Utility Functions

7.2.1 Undo

Reverses the last action performed in Ventsim Visual

7.2.2 Redo

Cancels to previous Undo, restoring any changes made.

7.2.3 Find

Searches for specific items within a ventilation network. Pressing the 'searchlight' icon directly, repeats the previous *find* action. Pressing the submenu arrow next to the icon, activates the find submenu as shown below.

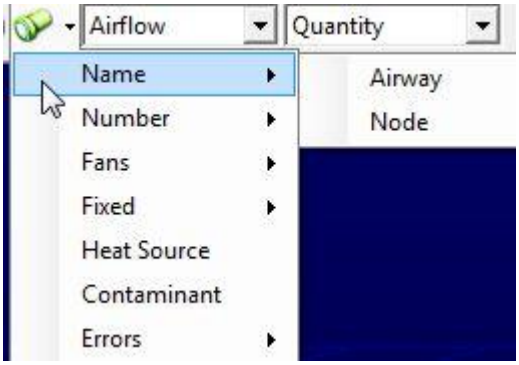


Figure 7-1 Find specific airways

Name Find the name of an airway name or node. Entering any part of the name will find airways containing the name part.

Number Find an airway with the specified index or unique number

Fans Find airways with operating fans, fans that are turned off, or fans that are performing outside of their rated fan curves.

Fixed Find airways with fixed flows or pressures.

Heat sources Find airways with artificially heat, cooling, diesel or moisture sources.

Contaminants Find airways with contaminant sources set.

Errors Find network errors defined during the previous simulation.

7.2.4 Data Category

Limits the data types shown in the adjacent pull down menu, to the category type specified.

Figure 7-2 Select a data category, followed by a data type

Airflow Show data types such as air flow volume, velocity, mass flow and density

Pressure Shows pressure related data such as relative to surface, barometric and friction loss.

Attributes Shows airway resistances, friction factors and shock loss numbers

Energy Shows power and cost calculations for airflow, fan and fix inputs

Heat Shows heat related data, such a temperatures, internal heat content, humidity.

Identifiers Show airway specific indentifying traits, such as index or unique numbers and primary and secondary layers numbers

Contaminants Shows airway contaminant factors, source values, simulated values, spread times and diesel particulate levels.

Rock Show airway rock conditions, such as wetness fractions, specific heat and other rock parameters.

Measured Not currently used.

7.2.5 Data Type

Displays screen data of the type specified in the pull down menu.

Warning: some data types (such a pressures) may not be correctly set until after a successfully simulation. While Ventsim Visual™ records previous simulated values in a saved file, these values may not be valid if further changes and modifications have been made to the network.

7.3 Airway Editing Functions

7.3.1 View

Places the program in *view* mode

Left Mouse Drag **Draw a window to zoom into part of a network**. The front most airway in the view window will define the point of focus for the zoomed in area. To zoom into area behind other airways, ensure the zoom window does not contain any portion of the front airways.

Left Mouse Click **Edit the airway.** Left clicking the mouse on top of an airway will show the Edit Box for that airway.

Middle Mouse Drag **Press and hold to pan** the screen horizontal around the current Edit Plane

Click to centre the Edit Plane and rotation point about a specific airway or point on the Edit Plane.

Right Mouse Click Rotate the network graphics about the point of focus. Hold and move the mouse vertically to tilt the network. Hold and move the mouse horizontally to spin the network.

7.3.2 Add

Places the program into draw (add) mode to allow creation of new airways or measurement between airways. The function has several sub-functions available by clicking the small arrow at the right.

In normal (free draw) mode, airways that are constructed joining from other airways will adopt the attributes of the joined airway (such as size and wall friction factors types).

Airways that are constructed away from other airways will adopt the default set in the ***Settings*** menu.

Left Mouse Click **Edit the airway.** Left clicking the mouse on top of an airway will show the Edit Box for that airway.

Left Mouse Drag Constructs a new airway from where the mouse is initially pressed, to the point where the mouse button is released.

To manually control the coordinates of the airway being constructed, select the sub-menu functions of the add button as shown below.

Figure 7-3 Manual airway drawing options

- **Free Draw** – allows the mouse to draw both ends of the airway. The coordinate entry box is not shown, unless an airway node or empty space is clicked.
- **Coordinates** – show the coordinate entry box after the airway is drawn to allow manual entry of airway end coordinates.
- **Measure** – allows the mouse to measure distances between two points. Click on the start point of where the measurement will start, and drag the mouse to the end point. The measurement will display in the bottom left Status Bar area of the screen.
- **Convert** – allows the selective direct conversion of DXF reference lines to airways. If imported DXF centrelines are shown as a reference layer on screen (instead of automatically being converted to airways on import), then this function can be used to selected click or fence the reference lines that are to be converted to airways. Note that each reference lines can only be selected once, as the program will not duplicate multiple selected lines.

7.3.3 Edit

Place the program into Edit mode

Left Mouse Click **Edit the airway.** Left clicking the mouse on top of an airway will show the Edit Box for that airway.

Left Mouse Drag **Selects the airways within the fence box being drawn**. Selected airways can then be edited by clicking on any of the selected airways.

Hint : Selecting Multiple airways permits attributes for a large number of airways to be changed simultaneously. This can greatly speed up creating a network.

7.3.4 Block

Blocks or unblocks an airway with the highest resistance available (as defined in the Settings menu). This will restrict nearly all airflow through the airway.

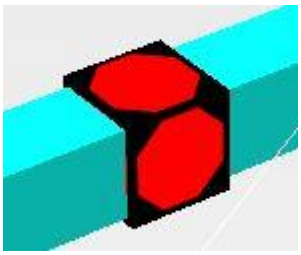


Figure 7-4 An airway stopping

Warning: Ensure that fans or fixed flows are not present in blocked airways, or in airways leading to or from blocked airways. This will create a simulation error, as airflow will be unable to travel through the blocked airway without unreasonable pressure or heat build-up.

7.3.5 Delete

Deletes an airway or airways from a network

Left Mouse Click **Delete the airway.** Left clicking the mouse on top of an airway will delete the airway beneath the mouse cursor. If multiple airways have been selected, it will delete all selected airways.

Left Mouse Drag **Selects the airways within the fence box being drawn**. Selected airways can then be deleted by clicking on any of the selected airways.

7.3.6 Move

Moves the selected airway, airways, airway ends or icons to a new location

- To move an airway end (and all other attached airway ends), *click* on of close to the end node of an airway
- To move an airway end away from other airways, *click* slightly back from the airway end node. The airway should 'break' away from other connected airways.
- To move an entire airway (both ends), first select the airway with the select button, or fence the airway to be moved, and then drag the selected airway(s) to the new location.
- Multiple airways can be moved by first *selecting* the airways and the dragging any one of the selected airways to the new location.
- To move an icon (such as a fan, heat source or resistance) along an airway, simply grab the icon with the left mouse button and drag the icon along the airway to the new location.

Left Mouse Click Opens the coordinate entry dialog box to allow the move to be specified as a coordinate or offset from the current position.

Left Mouse Drag Drags the airway or node to a new location in the same horizontal elevation plane. A 'true vertical' line is displayed showing where the move point is in relation to other airways.

Left Mouse Drag + Shift Drags the airway or node to a new location in the vertical plane, adjacent to the viewing screen. The Edit Plane is moved with the dragged airway to indicate where the elevation is in relation to other airways.

7.3.7 Copy

Copies the selected airway or airways to a different location. The original airways remain in place.

Left Mouse Click Opens the coordinate entry dialog box to allow the copy to be specified as a coordinate or offset from the current position.

Left Mouse Drag Drags the copied airways to a new location in the same horizontal elevation plane. A 'true vertical' line is displayed showing where the move point is in relation to other airways.

Left Mouse Drag + Shift Drags the copied airways to a new location in the vertical plane, adjacent to the viewing screen. The Edit Plane is moved with the dragged airway(s) to indicate where the elevation is in relation to other airways.

7.3.8 Reverse

Reverses the direction of the selected airway. The direction of the airway, and the airflow within the airway is reversed. Fan, fixed flows and pressures are also reversed.

7.3.9 Insert Node

Inserts a node or junction within an existing airway. The airway is split into two airways as a result. This node can then be moved or joined into by other airways.

Hint : Drawing an airway into the middle of another airway will automatically create a new node or junction into the joined airway.

7.3.10 Select

Selects a group of airways. Selected airways are considered 'attached' as a group by a number of other Ventsim Visual™ functions such as *Edit*, *Delete*, *Move* or *Copy*, which all treat selected airways are joined together.

Left Mouse Click Selects or de-selects the airway under the current mouse cursor.

Left Mouse Drag Fences a number of airways for multiple selection.

<Escape> De-selects all currently selected airways

7.3.11 Contaminant

Places a contaminant type within an airway. A number of different contaminant types can be chosen.

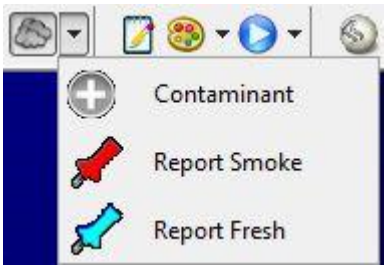


Figure 7-5 Contaminant placing options

Contaminant

Places a standard contaminant value of one hundred (100) in an airway. Standard contaminants are considered unit less, and represent the initial concentration of a contaminant in the airway's airflow. Downstream contaminants are diluted proportionally to this value.

Report Smoke

Used in the contaminant tracking routines, this will place a smoke report within an airway. After a contaminant tracking simulation, all airways below this point will be considered as contaminated. All airways upstream from this point will be considered as a potential source of the contamination.

Report Fresh

Again, used in the contaminant tracking routines, this will place a fresh air report within an airway. After a contaminant tracking finding simulation, all airways above this point will be considered as fresh air.

Left Mouse Click Places or removes one of the above types of contaminants.

7.4 Viewing Functions

7.4.1 Display Manager

Shows the Display Manager dialog box, which floats on top of the Ventsim Visual™ windows, and can be kept open at all times if desired.

The Display Manager control provides options as to what graphics details to display, primary and secondary layers, elevations levels, saved views and copy & paste options. Because complex display can quickly become cluttered with data and information, this dialog box is useful to reduce the amount of data (and hence clutter) in the display.

Hint : The Save View function from the ***Saved View Menu*** can be used to store specific display options settings, without having to go back through the dialog box and click specific items.

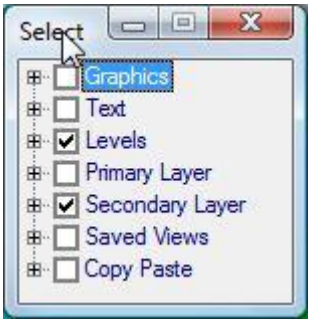


Figure 7-6 Display Manager Settings

Graphics **Displays the graphics details to show in the main window**. To show or hide detail, simply click the check box adjacent the item (such as nodes, or airflow arrows). To select *ALL* graphics, or *HIDE* all graphics, select the root check box adjacent ***Graphics***.

Text **Select the text data that is displayed on screen.**

- Value displays text data associated with the data type selected in the main menu
- Airway displays the name of an airway (if set)
- Node displays the name of a node (if set)

Text data can be further limited by restricting which airways show text (from the Edit Box) and choosing ***Text Data > Show Limited*** under the ***View Menu***

Levels Selects which levels (elevation ranges) are displayed on screen. To select or de-select **all** levels, choose the root check box adjacent to 'Levels'.

To change a level name, right mouse click on the existing level name and type in the new name.

Primary Layer **Selects which primary layers are displayed on screen**. Layers are a way to show selected airways (such as a decline system or a shaft system) on screen while hiding other airways. Primary layers can be set to individual airways in the Edit Box. To select or de-select all primary layers, choose the root check box adjacent to 'Secondary Layer'

To make a Primary Layer Active (which results in all new or imported airways adopting the layer name), click on the primary layer name so that it turns *RED*.

To change a Primary Layer name, right mouse click on the name and type in the new name. Primary names can also be changed directly from the airway Edit Box.

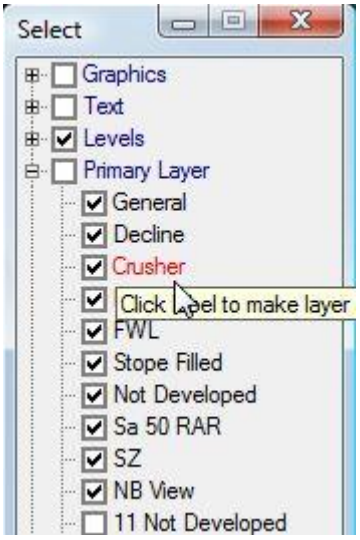


Figure 7-7 Setting Active Layer (Crusher) Display with the Display Manager.

Secondary Layer **Selects which secondary layers are displayed on screen**. Secondary layers are similar to primary layers, and simply allow another level or layers to be displayed. Primary and Secondary Layers work in conjunction with each other, and must both be set to allow an airway with the primary and secondary layers attributes to be displayed

> For example, if a particular airway is set in the Edit Box to a primary layer of 'Decline' and a secondary layer of 'East Mine' then both the Decline and 'East Mine' layers would need to be selected in the Display Manager. If either or both layer was not set, the airway would not be displayed.

To select or de-select all secondary layers, choose the root check box adjacent to 'Secondary Layer'

Again, to make a Secondary Layer Active (which results in all new or imported airways adopting the secondary layer name), click on the secondary layer name so that it turns ***RED***.

> For example, if a DXF string file is to be imported into Ventsim Visual, it is often of benefit to place it on a separate layer so it can be viewed or edited in isolation of other network airways. In this case, the primary and secondary layers to place the import would be clicked RED and the imported file would then appear on these layers. The layers could then be shown in isolation from other airways, by turning OFF the other layers.

To change a Secondary Layer name, right mouse click on the name and type in the new name. Secondary names can also be changed directly from the airway Edit Box.

Saved Views Recalls views saved under the SAVED VIEW main menu. This function duplicates the functionality already found under this menu.

Copy Paste Selects what airway attributes are copied and paste when the *copy / paste attributes* function is selected under the ***Edit menu.*** The copy paste attribute function allows rapid copy of existing airway attributes on to other airways. This

function duplicates the Edit Box functionality which also allows multiple airways to be selected and simultaneously changed.

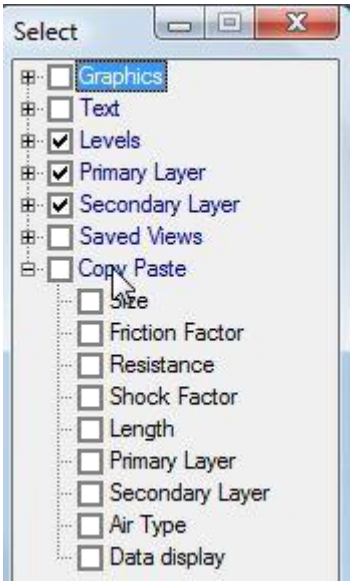


Figure 7-8 Copy and Paste attribute options selection

Example : An existing airway has been set as an exhaust airway with custom primary and secondary layers. To copy these attributes on to other airways,

- Select Primary, Secondary and Air Type options on the Select Box
- Select Edit > Copy Attributes
- Click the airway you wish to copy the attributes from.
- Select Edit > Paste Attributes
- Click or Fence the airways you wish to copy the attributes to.

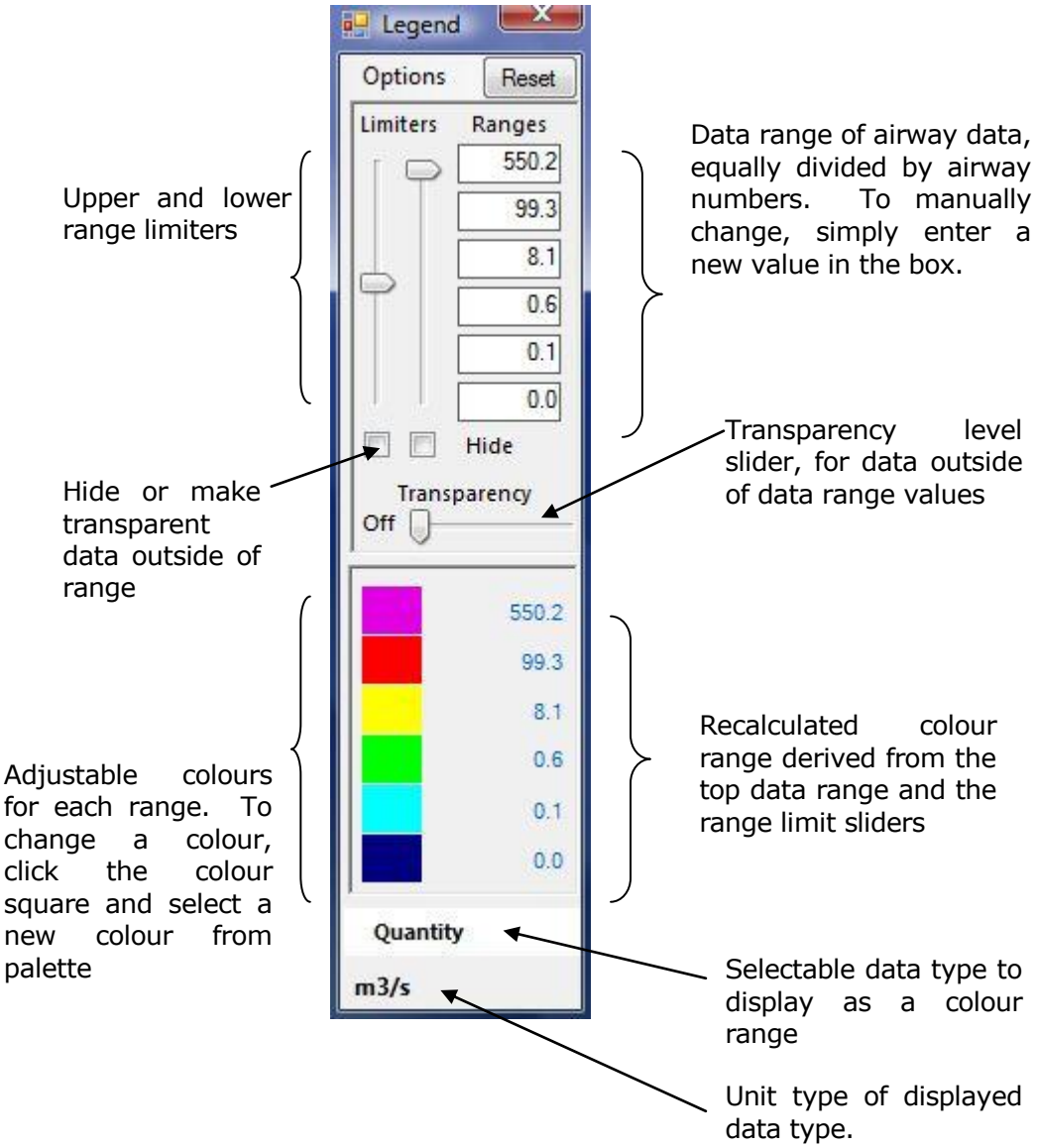
7.4.2 Colour Manager

The Colour Manager controls many of Ventsim Visual™ advanced display functions. At the core of the manager is the ability to display any type of ventilation data as a colour range, including the ability to hide or make transparent data outside of a set range.

Ranged Data. The data which creates the colour legend is automatically 'ranged' to fit the network data values. It may occasionally require resetting if new or changed values are present in a network (after a simulation for example), or the values do not divide the colours as you would like. The data can be re-ranged by either manual typing in new values, or allowing Ventsim to automatically choose new values by selecting the **Options** menu.

Median Range, will divide airways into a number of equal groups from highest to lower value, and take the average value for each group (useful for non-linear data like resistances which have a few very high values and lots of very low values).

Average Range establishes a linear legend from highest to lowest.



OPTIONS

Reverse Spectrum **Reverses the colour range** direction

Restore Colours **Restores the colours** to the default Ventsim Visual™ palette.

Auto Range **Restores the range** to the full spectrum of available airway data values.

Hint: The Colour Manager will initially default to automatically range and set colours for the displayed data. If the range values are manually adjusted, or the colours are changed, the Colour Manager will no longer automatically range and adjust colours for the data displayed. To restore or recalculate the range and colours, simply click the 'Auto Range' or 'Restore Colours' buttons.

Hint: Ventsim Visual™ will store a custom colour and data value range for each type of data type. This setting is saved with the Ventsim Visual™ file.

See Colour Manager for further information.

7.4.3 Colour Manager Sub Menu

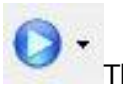
Figure 7-9 The Colour Manager sub menu

Show **Shows the colour manager on screen**. The Colour Manager will remain on top of all other windows while displayed.

Hide **Hides the Colour Manager form**

Colour Data **Automatically matches the colour display, to the data type shown** on the screen as text. The colour display and the text display are totally independent. This function will match the two items, to that text displayed on the airways on screen, matches the colour range displayed.

7.4.4 Flow Animation



The animation 'play' button animates the airflow arrows in the network. The airflow animation is performed at true scale speeds, with airflow arrows travelling at the simulated air velocities in the network. Providing the model is designed true to scale, the progress of airflow can be tracked at the same speed as expected airflow in the underground mine.

Figure 7-10 Animation Speed Control

The animate toolbar button has a number of sub menu items

X1 **Animates airflow at scale speed.**

X5 **Animates airflow at five (5) times** the scale speed

X10 **Animates airflow at ten (10)** times the scale speed

Stop **Halts the flow animation process.**

Hint: Clicking the main flow animation icon will cycle the airflow speeds through all available ranges.

7.5 Simulation Functions

The simulation functions control the major simulation capabilities of Ventsim Visual. The buttons assumes that a valid network has been created and all required data has been entered in preparation for simulation.

7.5.1 Airflow Simulation

Performs an airflow simulation on the network data.

For more information, see Airflow Simulation

7.5.2 Heat Simulation

Performs a thermodynamic simulation on the network data

For more information, see Thermodynamic Simulation

7.5.3 Contaminant Simulation

Performs a contaminant simulation on the network data. Contaminant sources or flag must be present in the network to work. Three different types of contaminant simulations are available from the sub menu pull down (arrow to the right of the icon). See the Run Contaminant Menu bar for more information.

Figure 7-11 Contaminant Options

Contaminant Spread **Spreads contaminant sources through the network**. The display and colour legend automatically switch to a contaminated concentration display, showing the simulated spread and contamination of the contaminants. See Contaminant Spread from the menu bar section for further information.

Hint : A number of additional contaminant data types are available including the 'spread time' of data.

Contaminant Source **Performs a source simulation**, where the sources of airflow through the contaminant are tracked back to an origin. The contaminant markers are used to define the point(s) at which the simulation searches upstream for paths. The display and colour legend automatically switch to a source concentration display, which shows the relative amounts of airflow along different airway paths which

eventually flow through the contaminant marker. See Contaminant Source from the menu bar section for further information.

Location Tool **Performs a contaminant search simulation** which tracks the likely paths of fresh and contaminated air. See Location Tool from the menu bar section for further information.

7.5.4 Diesel DPM [Advanced]

Performs a diesel particulate matter spread simulation based on diesel heat sources in a mine network. The result is displayed as a concentration per unit volume of airflow. The diesel heat sources are defined under the thermodynamic Heat Tab from the Edit Box form. Diesel heat sources are converted to a diesel particulate emission rate per unit of engine power, based on either a default setting, or entered directly in the Edit Box or Preset form. Diesel emissions are spread throughout the network using a steady state, complete mixing algorithm that assumes perfect mixing and no settling or deposition of particles. Diesel sources are assumed cumulative, and downstream sources or recirculation may increase concentration higher that the initial source.

The simulated air concentrations are given in the same emission type as specified in the exhaust emissions. For example if a total diesel particulate matter rate is given for a diesel engine (which includes elemental and organic carbon, as well as other matter such a sulphates and non-carbon matter), then the air concentration rates will also include this material. Most air quality standards will quote either an Elemental Carbon limit or a Total Carbon limit.

To convert to an Elemental or Total Carbon concentration, a factor will need to be applied either to the original emission rate, or to the simulated air concentrations.

See DPM emissions for further information.

7.5.5 Recirculation Simulation [ADVANCED]

Performs a recirculation search simulation which attempts to find any paths or portions of paths which recirculate in the mine. Any recirculation paths are highlighted after simulation. For further information, see Recirculation Simulation under the Menu Bar Chapter.

7.5.6 Financial Simulation [ADVANCED]

Performs a financial and airflow simulation for multiple airway sizes, to assist in determining the optimum airway size for mine ventilation flows. For further information, see Financial Simulation under the Menu Bar Chapter.

Chapter 8

Chapter 8 THE EDIT BOX

The edit box is a powerful tool required to manipulate and display airway attributes. In summary, the Edit Box can perform the following functions

- Set airway attributes for airflows and pressure simulation.
- Set airway attributes for heat simulation.
- Set contaminant attributes for airways
- Allow custom comments and information (such as survey results) to be set for each airway
- Display working fan duty curves
- Display airway information derived from simulation

The Edit Box can be activated by clicking on an airway while in the *View*, *Edit* or *Add* modes selected from the main toolbar. The Edit Box is divided into a number of TABS to allow quick access to each function.

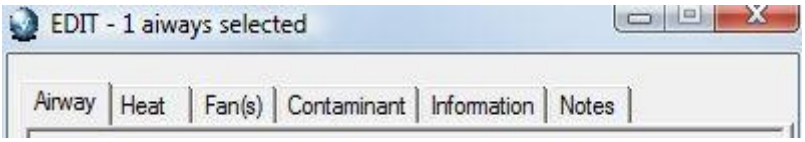


Figure 8-1 Edit Box Tabs

Changes made to the airways in the Edit Box are highlighted in BLUE. The changes are applied to the airway when;

- *Apply is pressed.* – the Edit Box form will remain open
- *OK is pressed* – the Edit Box form will then be close

If another airway is selected, the changes will be applied, and the next airway data will be displayed.

Multiple airways can be selected and simultaneously edited from the Edit Box. Note that not all Edit Functions are available for multiple editing and some function may be hidden. To utilise multiple airway editing, simply *Select* the required airways before the Edit Box is opened. Only attributes that are *changed* (and therefore highlighted in BLUE) are applied to the selected airway(s)

8.1 Airway Tab

The airway Tab Page controls most of the airway attributes associated with airflow and pressure simulation, as well as basic airway information such as names and airway coordinates.

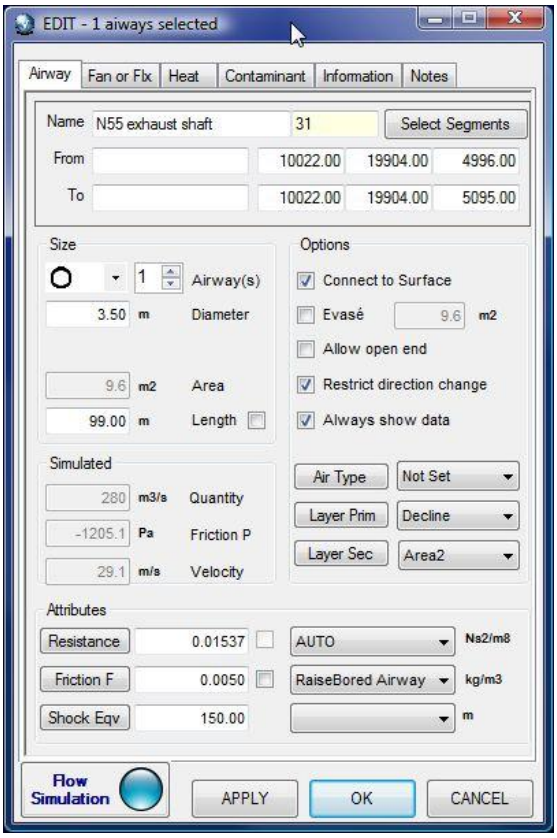


Figure 8-2 Airway Edit Box Form

8.1.1 Select Segments

At the top right of the form is a BLUE drop down function which will allow the selection of multiple airways based on a selection criteria. Multiple selected airways can be edited simultaneously from the Edit Box. The number of airways selected will be displayed in the form Caption Box (at the top of the form).

Select Joined Airways Selects all airways directly joined to the initial airway (for example a decline loop). The selection will stop when the airways reach a junction.

Select Same Primary Layer Selects all airways with the same primary layer

Select Same Secondary Layer Selects all airways with the same secondary layer

Select Same Size Selects all airways of the same size

Select Same Resistance Type Selects all airways with the same resistance type (eg bulkhead). This may be useful for group changing and testing different regulator types on network performance.

Select Same Friction Factor Type Selects all airways with the same friction type (eg 'rough blasted' walls).

Select Same Shock Type Selects all airways with the same shock type.

Select Same Fan Selects all airways with the same fan. Note that while fan types cannot be changed in multiple headings, however fans can be turned on or off over multiple headings.

Select Same Air Type Selects all airways with the same air type (for example 'exhaust')

Select Same Heat Type Selects all airways with the same heat type (eg trucks). This may be useful for example to rapidly change all similar heat sources in a network to a different heat source (for example change all Truck Models from ABC500's to ABC750's)

Select Loose Ends Selects all airways with one end that are not connected to others, and which are not flagged as connected to surface or marked as 'allow open end'. This function is useful for quickly editing new network creations (from a DXF file for example) which may have lots of dead ends and development stubs (eg truck bays) that need to be flagged or deleted to prevent no entry / exit errors in the simulation. Note that this function should only be used when all valid connections have been accounted for.

Select Both Loose Ends Similar to the loose end selection, but only selected airways with no connection on both sides.

Select Same Contaminant Type Select airways with the same sourcing contaminant type. This selection was included to allow rapid definition of different air types in a mine by using the contaminant finding function. For example is a 'smoke' sourcing pin was placed, all airways downstream will be turned 'red' for contaminated air. If a 'fresh air' sourcing pin is placed, all airways upstream will be turned 'blue' for fresh air. Once all entries and exhaust pathways to the mine are marked, similar airways can be selected and the air type for those airways could be changed to 'Fresh' or 'Exhaust or 'Intermediate' etc.

8.1.2 Airway Names and Coordinates

Sets the airway and node names, and airway coordinates. To set new names or coordinates, simply type the information into the relevant text boxes.

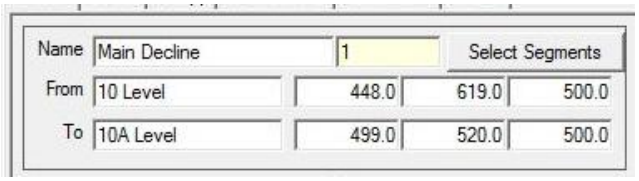


Figure 8-3 Set airway names and coordinates

8.1.3 Airway Size

Set the physical characteristics of the airway

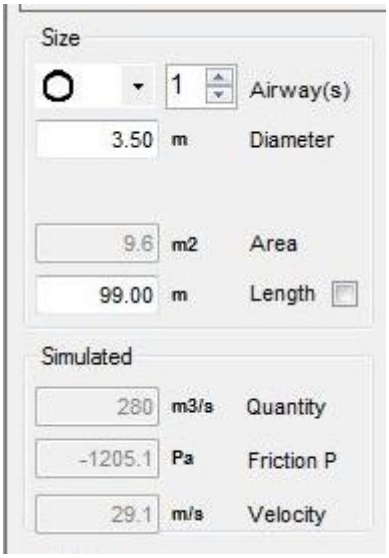


Figure 8-4 Set airway physical characteristics

Shape **Sets the shape of the airway**. If the shape chosen is 'irregular', the Width and Height input boxes will be changed to Perimeter. The Area box can be used to enter the actual airway area.

Square

Round

Arched – an airway with arched upper corners.

Shanty – an airway with one side higher than the other.

Irregular – an undefined shape characterised by area and perimeter

- If the shape chosen is 'round; the Width input box will be changed to Diameter.
- If the shape chosen is 'irregular' the Width input will be changed to Perimeter.

Number of Airways The number of parallel airways defined by the single airway. This allows multiple airways in parallel to be represented and simulated by a single displayed airway.

Width **The width of the airway**

Height **The height of the airway**. For vertical airways, the width and height are interchangeable. For 'Arched' or 'Shanty' airways, the height is assumed to be at the centre of an airway.

Area **The calculated area of the airway**, derived from the width, height and shape. If the shape chosen is 'irregular' then the Area box can be edited, otherwise it will remain as Read Only.

Length **The calculated length of the airway**. The calculated length is derived from the airway coordinates. To change the length, click on the Check Box, and type in

the new length. This may be required if an airway is moved to allow easier viewing, but the true original airway length still needs to simulated in the network.

Quantity **The calculated flow in the airway**. This number is Read Only and cannot be changed. To fix the flow in an airway, use the Fix Flow box in the Fan Section

Friction P **The calculated pressure drop in the airway**. This number is Read Only and cannot be changed. To fix the pressure in an airway, use the Fix Press box in the Fan Section

Velocity **The calculated velocity of air in the airway**. This is the average velocity of air across the airway area, and is 'Read Only' and cannot be changed.

8.1.4 Airway Options

Control various attributes relating to the airway behaviour and identifiers within a network

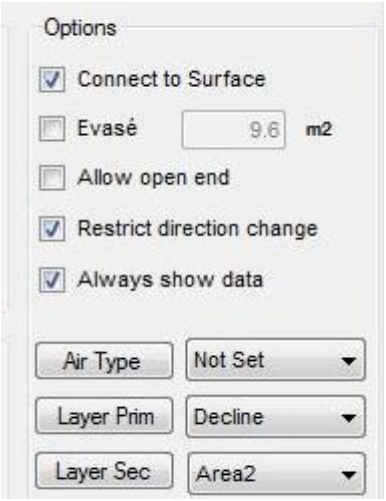


Figure 8-5 Further Airway Options

Connect to Surface Connects the airway to the surface, allowing it to freely exhaust and intake air from the surface atmosphere. The airway end which is not connected to any other airway is assumed to be the end connected to the surface. If both airway ends are connected, this item is ignored by the simulation. The exit to the surface is assumed to be at the elevation of the airway end. Barometric pressures at this point will be adjusted for any difference in height between the airway elevation and the defined surface elevation.

Evasé **Specifies an evasé for the airway outlet.** This function can only be used on surface connected airways, and will only have an influence on an exhaust airway. An evasé reduces exit velocity pressure losses to the mine, lowering overall total system pressure requirements to produce the same airflow. Where fans are present, an improvement in the performance of the fan will be noted with increasing evasé sizes. Note that the simulated evasé effect is theoretical only, and will ultimately depend on the efficiency and placement of the design to produce the simulated effects in a real mine. As with all ventilation structures, there will be some efficiency and shock loss factors that will reduce performance from the theoretical calculation. These should be considered when observing the effects of simulated evasés.

Allow open end. Allows Ventsim Visual™ to assume the airway ends without connecting to other airways or to the surface. Examples of this may include a dead end, blind developing heading or undeveloped heading. The simulation process will assume this path is blocked, and allow no airflow along the airway. Without setting this option, a simulation may end with an 'no entry' or 'no exit' error.

Restrict Direction Change Prevents Ventsim Visual™ from changing the airway's airflow direction during simulation. An error is displayed after simulation if an attempt to reverse is made. This function is useful to ensure critical airflow locations underground are not arbitrarily changed without first warning the user.

Always Show Data Always shows text data for this airway when the text view option is set to limited.

Air Type Sets the type of air the airway is carrying, for example fresh, exhaust, mixed etc. The air type can be shown as a separate colour on screen by selecting ***air type*** under the ***favourites*** menu on the Colour Manager.

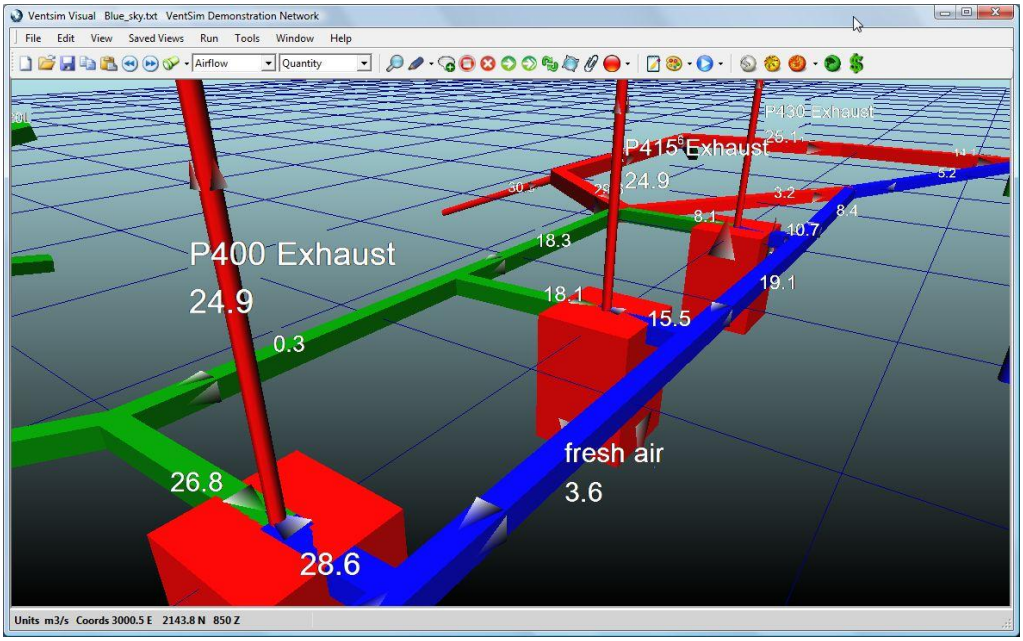


Figure 8-6 Example of use of fresh / exhaust airway colouring

Hint : Most mines have designated fresh and exhaust airways, and may also have airways which may be designated as potentially either, depending on production activities. Ventsim Classic 3.9 defaulted to a blue / red / green colour scheme for these three types of airways. Ventsim Visual™ uses these three air types, but also has potentially six other types (and colours) which can be specified under the Edit Box. Potential other air types could be set by the user as 'emergency access', flooded' etc.

Layer Prim **Sets the primary layer type of the airway**. Once set, primary layers can be independently displayed using the Display Manager. The name of the primary layer can be changed by clicking the ***Layer Prim*** button, and entering a new name in the preset spreadsheet.

Layer Sec **Sets the secondary layer type of the airway**. Once set, secondary layers can be independently displayed using the Display Manager. The name of the secondary

layer can be changed by clicking the *Layer Sec* button, and entering a new name in the preset spreadsheet.

8.1.5 Airway Attributes

Sets airway resistance, friction factors and shock loss factors for an airway.

The sort order of the attribute items in the list boxes can be specified in the Preset Manager

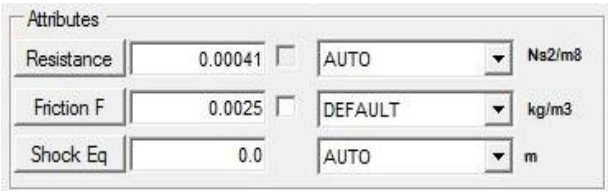


Figure 8-7 Resistance, Friction and Shock Factors

Resistance **Set the resistance for the airway**. Resistance can be set to automatic, preset or fixed.

To set to automatic, and allow Ventsim Visual™ to calculate the resistance from the airways size and wall friction factors, choose *Automatic* from the pull down menu.

To use a preset value, selection of one of the one hundred preset airway resistances from the pull down menu. To set a new Preset Resistance or change an existing one, select the Resistance Button to enter the Preset Spreadsheet and enter or change any existing resistance values from the Preset Spreadsheet. When the Preset Spreadsheet is closed, the new preset resistances will be available in the pull down menu for all airways.

To enter a fixed or one-off resistance value (which may be measured or pre-calculated elsewhere), enter the value directly into the resistance text box.

One way Resistances Resistances are normally set to apply equal resistance to airflow in either direction, however in Ventsim Visual, resistances can be specified to apply a different resistance when airflow is reversed. To enable this function, ensure a preset resistance is present in an airway and select the 'Restrict/Prevent Airflow Reversal' option in the Edit box. This will force the simulation to consider an alternative resistance if the airflow is reversed. Example of use for this function include resistances such as hanging flaps or swinging doors which may either seal better, or alternatively swing open if airflow is reversed.

To specify the reverse resistance, use the preset spreadsheet to enter the values. To apply a default reversal resistance (specified in the Settings menu) leave the reversal resistance at zero (0).

Resistance Density Adjustment Next to the resistance text box is the density adjustment check box. Resistance can change according to the air density at which it is applied. Ventsim Visual™ will internally adjust resistances during simulation according to the local air density.

- If this box *is not* checked, the resistance entered is assumed to be derived from a standard air density as specified in the Settings Menu

for Simulation – Air (which is normally 1.2kg/m3 unless set otherwise). In most cases, resistances are likely to have been derived from preset values and standard air densities, and this option should remain unchecked.

- If the box *is* checked, Ventsim Visual™ will assume an adjustment has already been included and will not attempt to adjust the resistance from density changes further. Examples of this may be if the resistance has been measured at a specific site underground at a density similar to that simulated by the program.

Friction F Set the friction factor for the airway. Friction factors describe the unevenness of wall profiles, which produces airflow turbulence and hence pressure loss. The value can either be entered directly in the Friction F text box, or can be selected from the pull down menu. As with resistance, new preset values can be entered by clicking the Friction button, and entering new preset values in the Preset Spreadsheet. The new Preset Friction Factors will be available for all airways.

Friction F Density Adjustment Similar to the resistance density adjustment, friction factors are also standardised to an air density, and need to be adjusted for different air densities. Ventsim Visual™ will internally adjust friction factors during simulation according to the local air density. If this box *is not* checked, the friction factor entered is assumed to be derived from a standard air density as specified in the Settings Menu for Simulation – Air (which is normally 1.2kg/m3 unless set otherwise). In most cases, friction factors are likely to have been derived from preset values and standard air densities, and this option should remain unchecked.

If the box *is* checked, Ventsim Visual™ will assume an adjustment has already been included and will not attempt to adjust the friction factor further. Examples of this may be if the friction has been measured along a specific airway underground at a density similar to that simulated by the program.

Shock Loss Factors **Sets a shock loss factor for the airway.** Shock losses can be set as an equivalent length, or as a shock loss factor (X). The method used is defined in the Settings.

Only one method can be used for all airways, so ensure shock values are consistent with the chosen method throughout the network.

Shock values can be manually entered in the text box or set to a ***Preset Value*** or to ***Automatic*** value from the pull down menu at the right. To change or establish new ***preset values***, press the Shock button, and enter or change the values in the Preset Spreadsheet.

If ***Automatic*** is chosen, Ventsim Visual™ will attempt to recalculate a new value during simulation, by observing airflow direction, airway geometries and airway size changes. Note that this is a rough estimation only and may change slightly with every simulation due to changing airflow and directions. In critical areas which are subject to high airflows and large shock losses, a more thorough examination of airways should be performed, and the shock factor settings manually calculated and used. Guides in setting Shock Value are available in most quality ventilation texts.

8.2 Fans

Displays a form allowing fan and fixed flow and pressure settings to be established in an airway. If a fan is present, a fan curve graph and duty will be displayed after simulation showing fan performance in a simulated network airway. If no fan is present in the airway being edited, a blank window will be displayed.

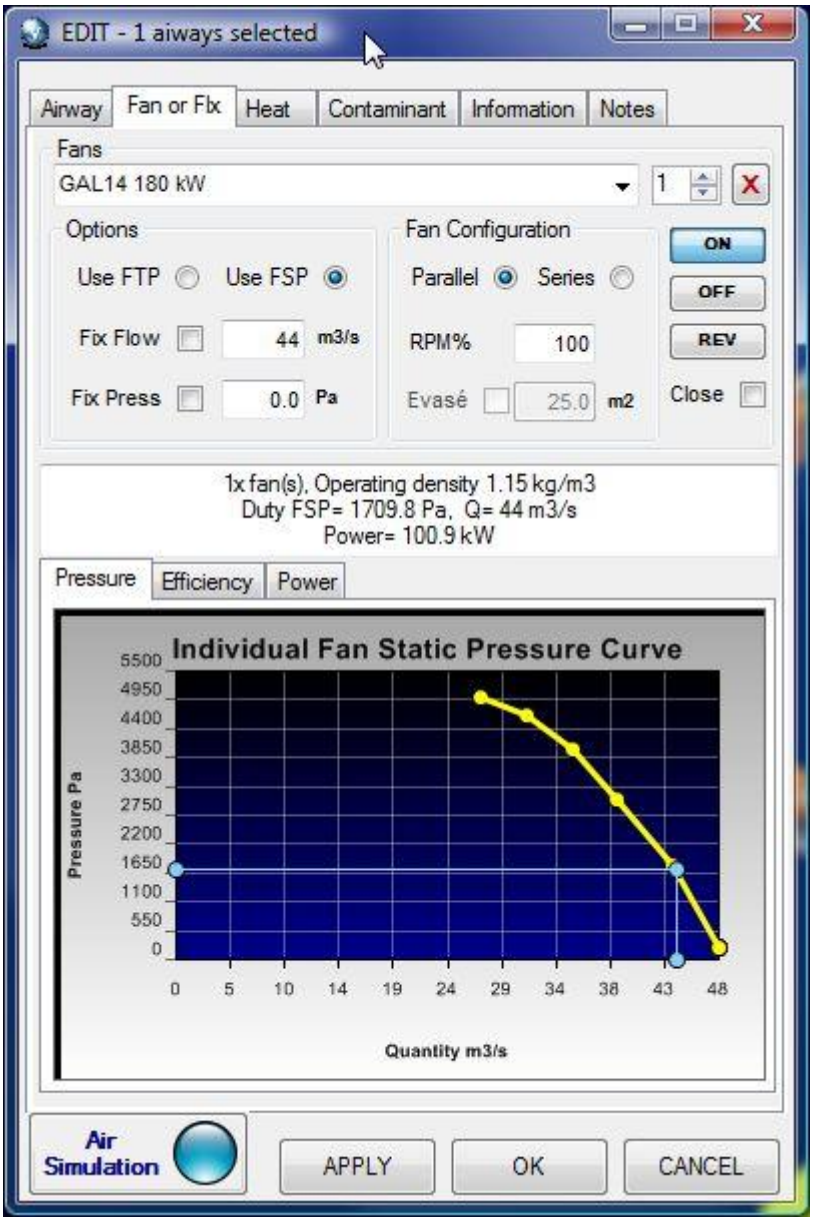


Figure 8-8 Edit Box Fan Information

Fan and Fix Settings **Sets fans, fixed flows or fixed pressures within the airway.** This setting provides the motive force which moves air around a flow network. Without at least one airway within a network containing a fan or a fix, there will be no airflow within a network (unless natural ventilation pressures are present)

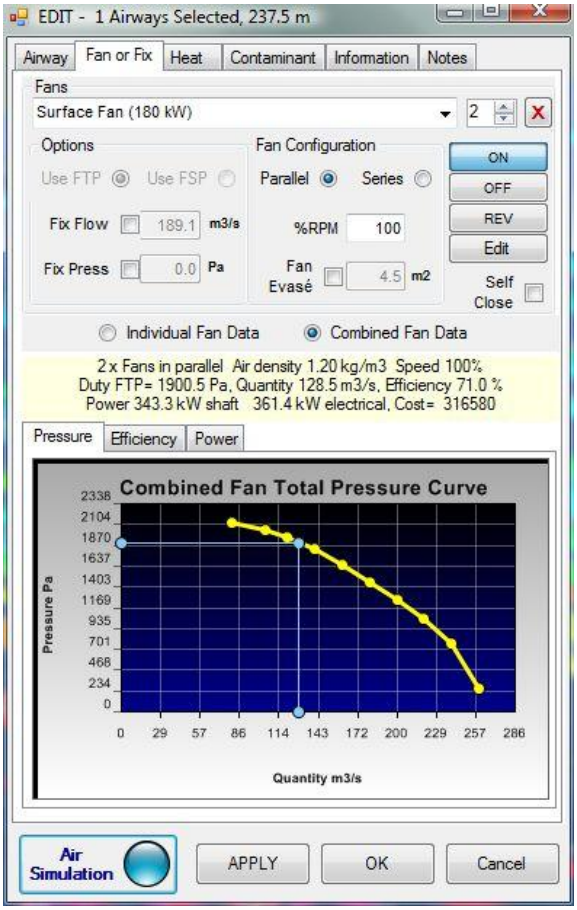


Figure 8-9 Fan and Fix Settings

Fan Name, Number and Configuration

Selects a fan for the airway. The upper pull down menu allows a fan to be selected from the fan database. Fans are sorted alphabetically. Adjacent to the fan name, is the number of fans to be included in the network, and below this is the configuration of the fans (parallel or series). Fans installed in parallel will increase available fan pressure according to the number of fans available, while fans installed in parallel will increase available airflow.

Selecting the X will remove the fan from the airway. Selecting EDIT will jump straight to the fan curve database edit screen.

Use FTP
Use FSP

Selects the type of fan curve to use in the network simulation. FTP is a Fan Total Pressure curve while FSP is a Fan Static Pressure curve. This is normally automatically controlled from the Simulation Settings for Fan Pressure Type under the Simulation – Air menu, which defines whether a Static, Total or Mixed pressure solution will be used.

If a Mixed Pressure solution setting is selected, individual airways can be set with different fan curve types. If the Static or Total method is selected in the Settings, Ventsim Visual™ will automatically use the corresponding fan curve, and the user will be unable to change the curve from the Edit Box.

Hint: As discussed elsewhere in the manual, the Total pressure method is the technically correct way to simulate a network, while the Static pressure method produces more conservative pressure and airflows which are potentially more robust if

shock losses and airway resistance are not correctly set. The Mixed method allows complete control over fan curves used and may be a choice if some types of fan curves are unavailable, or complete compatibility with Ventsim Classic 3.9 is required.

Fix Flow **Forces the simulation to produce an airflow** equivalent to the entered value in the box. A fixed flow cannot be set when a fan is present, and a fan will be removed if the fixed flow is checked. To remove the influence of the fixed flow, simply uncheck the fix check box. When a fixed flow is simulated, the program will calculate a required pressure and power to produce the fixed flow. Where the fixed flow is less than what would normally be simulated, the fixed flow acts as a 'resistance' or negative pressure influence, and restrict flow. In both cases, the results of fixing a flow will be displayed in the ***INFO*** box.

Fix Press **Forces the airway to produce a constant positive pressure** equivalent to the entered value in the box. This pressure will be in addition to any losses from friction within an airway. A fixed pressure cannot be set when a fan is present, and a fan will be removed if the fixed pressure is checked. To remove the influence of the fixed pressure, simply uncheck the fix check box. When a fixed pressure is simulated, the program will calculate the required airflow and power to produce the fixed pressure. The results of fixing a pressure will be displayed in the ***INFO*** box.

ON **Turns on the fan or fix during simulation** enabling the item to influence airflow within the network

OFF **Turns off the influence of the fan or fix during simulation**. The airway and network will behave as if the fan or fix is not present.

REV **Reverses the fan blade direction during simulation**. This item is useful for emergency simulation where fans are available in the network to reverse airflow at specific locations. The fan curve is adjusted by the reverse factors set in the fan database, to reflect the poorer performance of fans with blades run in reverse. The reverse function is only available for fans, not fixed flows or pressures.

EDIT **Enters the fan database screen to view or adjust fan data**. Note that any fan changes will not be reflected in the EDIT box until after a simulation.

Close **Closes the airway when a fan or fix is turned off.**

Many actual fan installations have a mechanical device which shuts off airflow when a fan is turned off or loses power. The self closing option allows the simulation to reflect this. If this option is unchecked, airflow will be allowed to flow freely back through the airway, just as if the fan is not present. Activating this option will close the airway; preventing airflow when the fan is switched off.

%RPM **Adjusts the fan blade rotation speed** from the standard setting defined in the Fan Database. Note that this is a theoretical pressure and flow adjustment which may not exactly meet true fan performance at different speeds.

Hint: While the simulated speed adjustment to a standard fan curve should be reasonably accurate, if an exact fan pressure and flow curve is required for fan performance at different revolutions, it is suggested a separate manufacturer guaranteed fan curve be entered for the adjusted variation.

Evasé **Simulates the effect of an evasé on an airway exhausting to the surface.** This function is identical, and duplicates the function found on the initial page tab. Evasés can be placed with or without a corresponding fan or fixed flow, but only on surface connected airways, and only if the Total Pressure method is chosen in the settings. The Total Pressure method simulates lost total pressure, in the form of escaping velocity pressure from a mine, and by reducing velocity pressure losses, evasés provide some static pressure recovery for the mine which can improve airflow and fan performance on the evasé airway, or elsewhere in the mine.

8.2.2 Fan Duty Point

The fan duty point states the air density the fan is running in, as well as an exact fan pressure and airflow volume the fan is simulated to operate at. Note that either an **individual fan duty** can be selected, or if multiple fans are present at the installation in parallel or series configuration, the entire **combined installation duty** can be displayed.

The fan pressure will be returned as a Static or Total pressure, depending on the pressure method set in the Settings – Air Simulation section. The efficiency returned reflects the efficiency curve entered with the fan. The efficiency curve is the shaft efficiency of the fan. It does not include electric motor or drive inefficiencies, which are considered separately in the Settings menu.

> Hint : Fan operating density is an important specification for designing fan types and installations. Higher air densities will increase the available operating pressure curve (and power draw) for the fan, while lower air densities will have the reverse effect. This can be an important consideration when selecting or designing a fan for a particular area in a mine. Note that for Ventsim Visual™ Standard, air densities are assumed fixed at all locations in a mine.

8.2.3 Fans Stalled, Low Pressure or Negated

If fans are forced by other network conditions to run beyond the limits of the fan curve, a warning showing stalled, low pressure or negated will be shown during network simulation.

Stalled fans occur when the fan pressure build-up is greater than the capacity of the fan curve to accommodate. Ventsim Visual reduces the airflow quantity to a point where the fan pressure is no more than the maximum pressure specified in the fan curve.

Low Pressure fans occur when fan pressure falls below the lowest pressure point of the fan curve, but are still operating above a zero pressure. This may occur when a fan is run with too little resistance or the fan is a high pressure type, being used in a low pressure application. The fan pressure curve in this case will not extend down to the point the fan is operating at. This is undesirable as the program must make assumptions as to what duty point the fan is actually running at. In addition the fan in unlikely to be running efficiently at this duty point.

Negated fans occur when the fan offers no useful pressure to the system ventilation pressures, and may even retard airflow that would otherwise flow more freely without the fan. This may be a result of other network factors or fans forcing air through the fan.

When Ventsim Visual encounters a low pressure or negated fan situation, it applies a resistance for airflow through the fan above the highest curve quantity.

This mimics real life performance of fans and effectively restricts airflow moving through a fan above its limit. The induced resistance results in an additional pressure drop and in negated situations, the fan may apply a negative or 'resisting' pressure, effectively acting as a 'brake' for the airflow.

Any of these situations are not desirable, as fans are not designed to run beyond their fan curves, and without a fan curve Ventsim Visual is forced to approximate fan performance and power consumption. While stalled, low pressure and negated warnings can be ignored, every effort should be made to reduce or eliminate these occurrences within a network.

8.2.4 Fan Pressure Curve

The fan pressure curve associated with the fan (or fans if **combined** is selected) in the airway. Note that the fan curve may have been adjusted by the simulation from the curve entered in the fan database, to reflect the change in air density at the fan location. The fan operating duty point is shown at the intersection of the horizontal and vertical lines.

8.2.5 Fan Efficiency Curve

The efficiency curve and the airflow volume intersection point define the efficiency the fan is operating at. The efficiency value is used to calculate the estimated fan shaft power. If fan shaft power is entered in the database directly, a fan power curve will be shown and the program will derive shaft power from this curve instead.

8.2.6 Fan Power Curve

If a power curve has been entered for the fan, the power curve and the airflow volume intersection point will define the shaft or absorbed fan blade power the fan(s) are operating at. If the power curve has not been entered for the fan, the efficiency curve will be used to calculate power. If this is not present, the default efficiency in the settings menu will be used.

8.3 Heat Tab (Advanced Version)

[ADVANCED] The heat Tab Page controls most of the airway attributes associated with heat and moisture simulation.

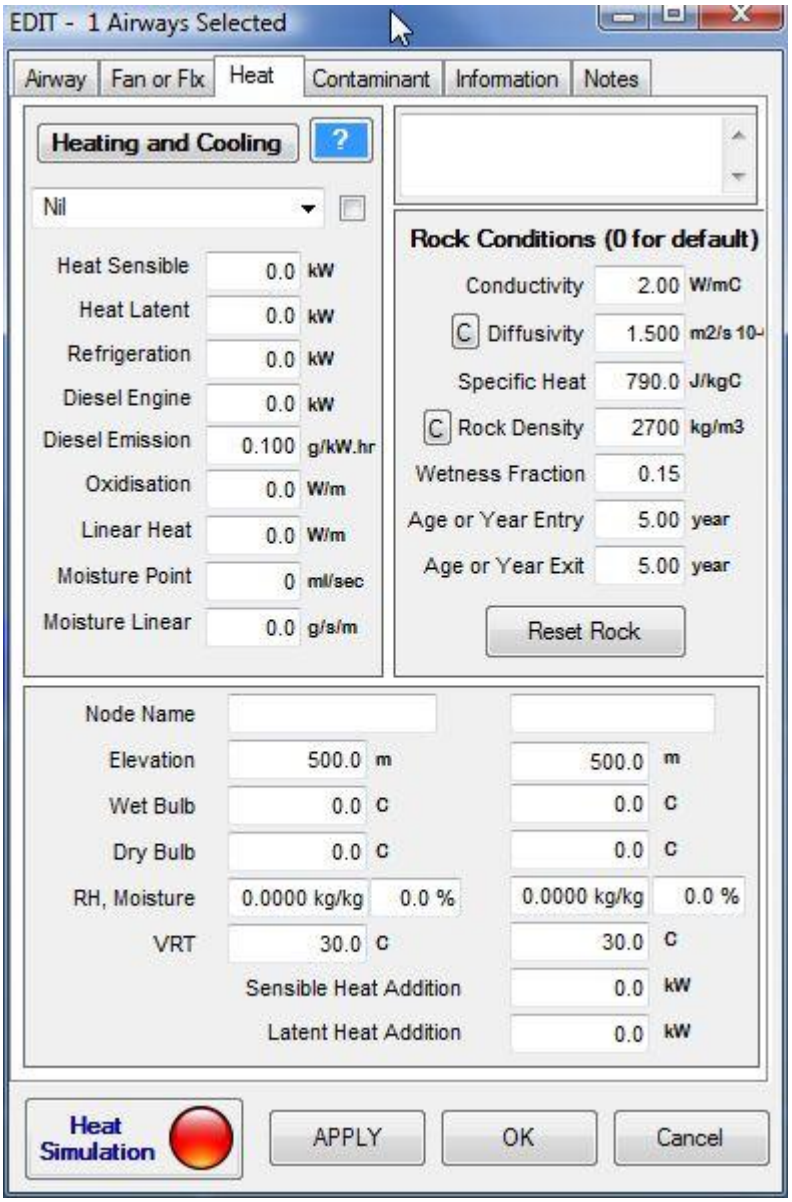


Figure 8-10 The Edit Box Heat Entry Tab (Advanced Version Only)

8.3.2 Airway Description

Duplicates the Airway Tab airway description box, but gives the user more space to place more detail in the name. This may be useful to provide more detail about the type or function of any heat input present in the airway.

Figure 8-11 Airway text information entry

8.3.3 Heat and Cooling

Sets the heating, cooling and moisture inputs for the airway.

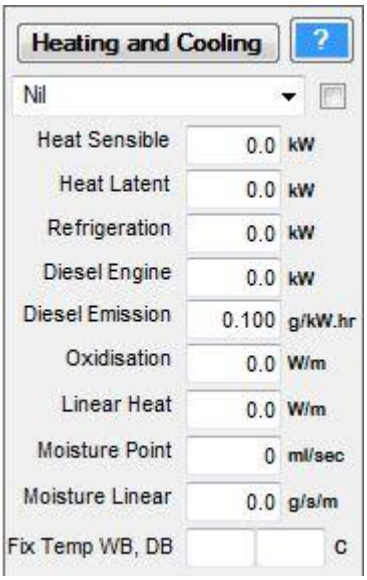


Figure 8-12 Heat Cooling and Moisture Settings

Heat Assistant Calculator The Heat Assistant helps the user calculate or estimate heat and moisture values to place within airways. The heat assistant calculator is described further in the next Chapter.

Preset On or Off (check box) The check box allows heat and cooling presets to be turned on or off, while leaving the preset in the airway. If the box is unchecked, the preset will have no effect on the network thermodynamics. Presets which are turned off will show in the network as a grey colour. Note that custom heat values which are not presets cannot be turned on or off, and must be removed if no thermodynamic effect is desired.

Heat Sensible **Adds (+ve) or removes (-ve) sensible heat from the airflow**. The number will be coloured RED (+ve) or BLUE (-ve) according to the heating or cooling effect of the value. Sensible heat is added or removed without changing moisture content. If sensible heat is removed, and the air temperature dips below the dew point, moisture will condense and will be removed from the air by the simulation.

Heat Latent **Adds (+ve) or removes (-ve) latent heat from the airflow**. Latent heat is sometimes describe as a 'moisture' heat and does not directly change the air temperature, but rather increases (+ve) or reduces (-ve) water vapour from the air. The Sigma Heat and Enthalpy increase with latent heat addition.

Refrigeration **Removes sensible heat from the airflow**. If heat is removed, and the air temperature dips below the dew point, moisture will condense and be removed from the air by the simulation. Refrigeration is essentially the same as placing a negative Sensible Heat, and is included as a separate item to clarify its intended function within the network analysis.

Diesel Engine

Adds a combination of sensible and latent heat to the air to simulate a diesel heat source. The result is generally a warmer moister air flow after application. The ratio of sensible and latent heat added is controlled by the diesel to water ratio set in the settings menu.

Diesel Emission An optional value used for Diesel Particulate Matter simulation which **defines the total amount of diesel particulates emitted** by an engine over a period of time for each unit of engine power. This can be derived from manufacturer's specifications or by practical testing of exhaust emissions.

Note this value is likely to include all particulate matter including elemental carbon, organic carbon and other trace matter. Atmospheric levels are normally limited to elemental or total (elemental + organic) carbon levels, therefore either emission rates or final simulated results will need to be scaled accordingly.

Oxidisation **The amount of heat per linear length generated by oxidising material in airway walls.** While oxidisation is not a significant factor in most mines, exceptionally reactive sulphide or carbonaceous material may have a significant effect where airflows are low or airway drives travel an exceptional length through highly oxidisation material.

Linear Heat **Adds sensible heat per unit length of the airway**. The value is intended to define heat sources which emit heat over a long length (such as conveyor belts). Setting a single equivalent point sensible heat to each airway will produce the same heat result.

Moisture Point **Adds (or removes) moisture in an airflow**. Moisture addition has a neutral effect on airway heat content, and is therefore added without changing the Sigma Heat content of the airway. The effect of adding moisture is therefore an 'evaporative' effect which reduces dry bulb temperature. Removing moisture will produce the opposite effect. Example of adding moisture to the air may include an evaporative cooling chamber or a dust suppression scrubber. Directly removing moisture from air (without cooling) although technically possible, is not a common mine process, and this option in Ventsim Visual™ would only normally be used to 'condition' air to a certain temperatures and humidity for simulation purposes.

Moisture Linear **Adds (or removes) moisture per unit length** of airway. Similar to the moisture point addition, this less commonly used function may be of value is simulating a long length of airway water addition, such as decline dust suppression sprays.

Hint : How much moisture as being added to your airways from sprays? To practically assess the amount, take a wet and dry bulb temperature above and below the sprays, and use the Ventsim Visual™ Heat and Moisture Calculator to estimate the change in moisture content.

Fix Temp WB, DB **Allows the use to fix the wet and / or dry bulb temperature** of the outlet air from the airway. This forces the heat simulation to adjust the air temperature from any previous simulated heat temperature upstream, to the fixed values. The corresponding heat and moisture values required for the transition will be calculated and reported after simulation. This function may have several useful functions

To adjust air temperature to a known value at a certain location, without having to modify simulated results above this location

To predict the heat or cooling required to condition the airflow to the fixed temperatures.

> Hint : Fixing the air temperature requires an adjusted to both sensible and latent heat content of the air. Entering the wet and dry fixed values as the **same** temperature forces the simulation to assume a pure 'refrigerative' condition which is converted to sensible heat and condensation, instead of the normal sensible and latent heat calculation. This is useful for determining refrigerative loads required for producing particular airway conditions. Note that there still may be some residual latent heat reported for the airway due to strata heat and moisture transfer.

8.3.4 Rock Conditions

Sets specific rock conditions for the airway. Airways will normally source these values from the default values in the Settings menu, however they can be individually overridden for each airway. Using these functions, it is possible to set parts of the mine with different rock parameters types or wetness fractions.

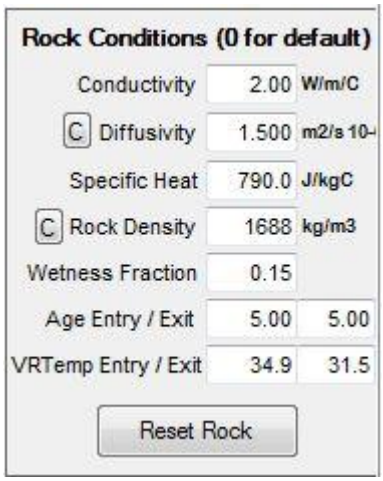

Rock Conditions (0 for default)
Conductivity 2.00 W/m/C
C Diffusivity 1.500 m2/s 10-
Specific Heat 790.0 J/kgC
C Rock Density 1688 kg/m3
Wetness Fraction 0.15
Age Entry / Exit 5.00 5.00
VRTemp Entry / Exit 34.9 31.5
Reset Rock

Figure 8-13 Rock Condition entry for airways

Thermal Conductivity **The thermal conductivity of rock surrounding the airway**.

Thermal Diffusivity **The thermal diffusivity of rock surrounding the airway**. This value is optional and can be derived by entering the rock density instead.

Specific Heat **The specific heat value of rock surrounding the airway**.

Rock Density **The density of rock surrounding the airway**. This value is optional and can be derived by entering the thermal diffusivity instead.

Wetness Fraction **The fraction of the airway surface which is wet**. A value of 0.01 would describe a nearly dry surface, while 1.0 would describe a fully wet surface.

Age or Year Entry **The age in years since the start of the airway was mined** (in decimal years, for example 4.5), or the calendar year of mining (in decimal format, for example 2005.5)

Age or Year Exit

The age in years since the end of the airway was mined (in decimal years, for example 4.5), or the calendar year of mining (in decimal format, for example 2005.5)

> Airway ages can be a mixture of calendar years and age in years. Ventsim Visual™ determines which age type has been entered by the number of digits in the date field. Four (4) digits indicate a calendar year age. Where calendar year ages are entered, airway ages are calculated from the Current Calendar Year age set in the Settings Menu.

VRTemp Entry / Exit **Manually sets the Virgin Rock Temperature at the start and end of an airway.** This function is unlikely to be used often. It forces the heat simulation to use preset rock temperature values, instead of calculating the rock temperature from the geothermal gradient. This function may be of assistance if the rock does not conform to the geothermal gradient parameters (for example mining through backfill) or the rock temperature is being modified by other factors such as local geothermal sources or reactions.

Note that the values normally reported in these cells are calculated from the simulation and will change with depth and time. To FIX the values to permanent temperatures, simply overwrite the pre-existing calculated values.

RESET ROCK Reset the rock conditions to those specified in the Settings menu. If any value is entered in the above catagories, the item will be 'hard coded' and will not change even if the default settings are changed. To reset all items, press this button. To reset an individual item, simply enter zero (0) in the field.

8.3.5 Heat Simulation Results

Displays the results of heat simulation on the airway. The data displayed in Read Only' and is for information purposes only. Most of the values displayed are self explanatory. More detailed airway information is available under the Information Tab.

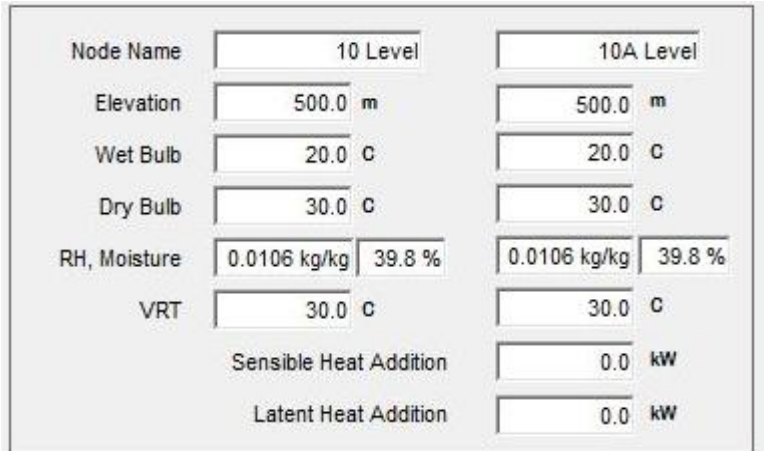


Figure 8-14 Heat Simulation Information

Elevation The calculated elevation of the start (left) and end (right) nodes of the airway.

Wet Bulb The calculated wet bulb temperature at either end of the airway.

Dry Bulb The calculated dry bulb temperature at either end of the airway.

RH Moisture The calculated relative humidity and the moisture content of the air.

VRT The calculated virgin rock temperature at either end of the airway. This value is calculated from the geothermal gradient, the elevation of the airway and surface rock temperature settings.

Sensible Heat Addition **The total sensible (dry) heat addition to the airway**, from rock strata and any user sensible heat inputs into the airway

Latent Heat Addition **The total latent (wet) heat addition to the airway**, from rock strata and any user latent heat inputs into the airway.

8.4 Contaminant

The contaminant tab display several options and settings required for contaminant simulation in a network.

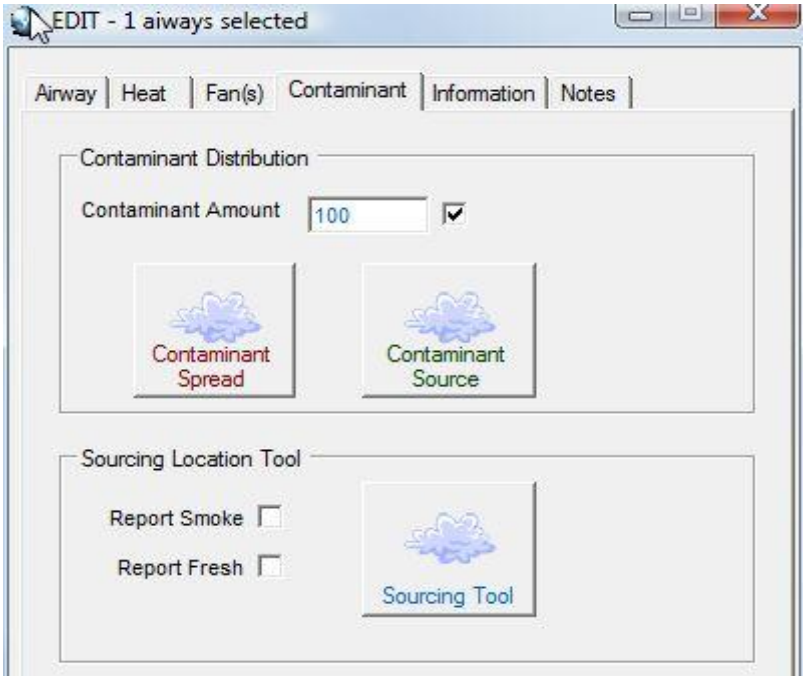


Figure 8-15 Edit Box Contaminant Input

Contaminant Amount Places a dimensionless contaminant value into the airway. The value is proportional to the airflow in which it is entered, and could be considered as a percentage, part per million (ppm) unit or any other unit which is representative of a value per unit volume of air. Clicking on the check box adjacent the value box, will automatically set or remove a value of one hundred (100).

8.4.2 Contaminant Spread Button Activates the Ventsim Visual™ contamination spread simulation process. Results are displayed on the screen if the simulation is successful.

See Contaminant Spread menu item for further information.

8.4.3 Contaminant Source Button Activates the Ventsim Visual™ contamination source simulation process. Results are displayed on the screen if the simulation is successful.

See Contaminant Sourcing menu item for further information.

8.4.4 Sourcing Location Tools Provides options for setting contaminant reports and simulating possible location sources of contaminants underground.

Report Smoke Places a smoke report in the airway.

Report Fresh Places a fresh report in the airway.

Sourcing Tool Button Activates the Ventsim Visual™ contaminant location tool. Results are displayed on the screen if the simulation is successful.

See Location Tool menu item for further information.

8.5 Information

The information tab provides a list of detailed information of settings and simulated values for an airway. The list may be copied to the Windows clipboard for pasting in another application such as Word or Excel. This can provide a valuable tool for comparing changes in specific airways before and after simulation.

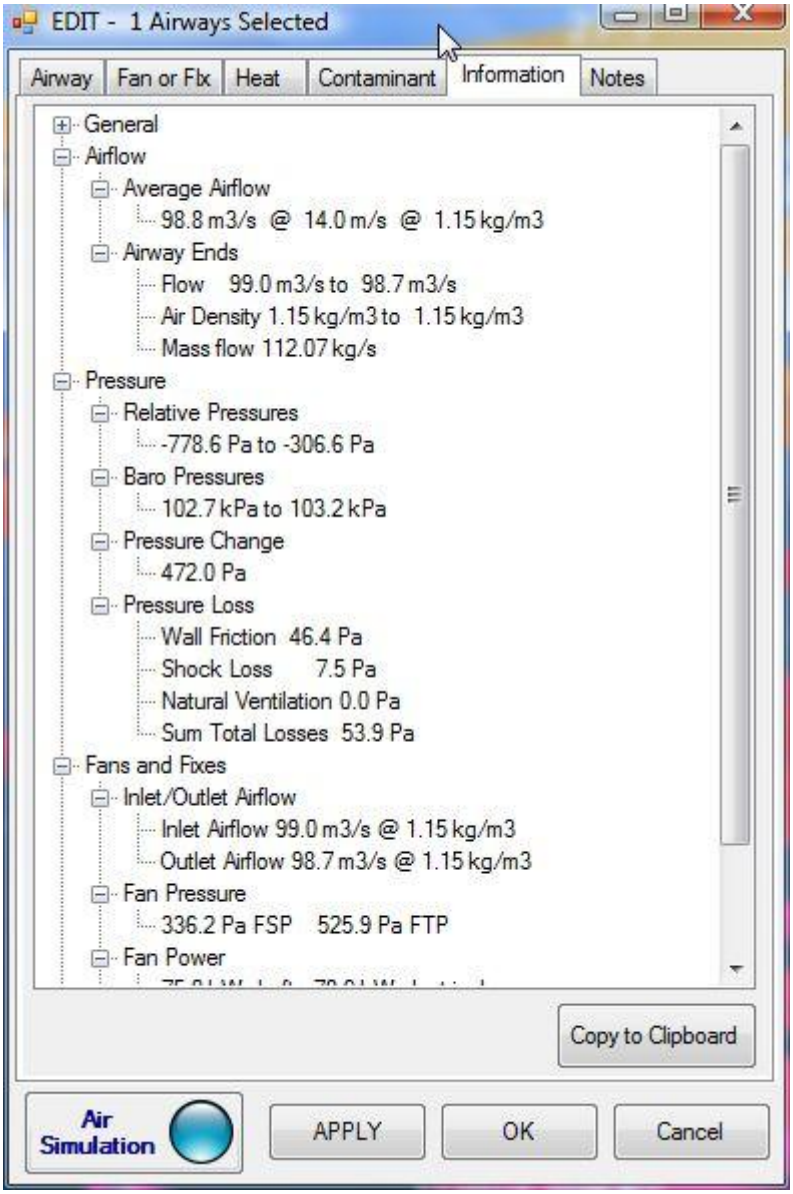


Figure 8-16 Airway Information Tab

While most data values are self explanatory, some notes below provide further explanation.

8.5.1 Fan and Fixed Information

An airway with a fan, fixed flow or fixed pressure will display the specific pressures, power and cost of the fan or fix for the airway installation. Unlike the Fan Tab, the pressures and volumes displayed will be for the entire fan installation (if more than one fan present), not for individual fans.

Fan Present

Fan Pressure Fan pressures are derived directly from the pressure volume curve of the fan. If the Fan Total Pressure (FTP) method is used, the duty point will be simulated from the FTP fan curve, and static pressure will be derived from the fan diameter or airway size. For the Static Pressure (FSP) method, the duty point is simulated from the FSP fan curve and the total pressure derived for the fan or airway size.

Special consideration is required for surface exhaust fans. For an exhaust surface fan, by definition, the Mine Total Pressure (loss of total pressure across all mine resistances) at the collar (inlet) to the fan is equal to the required Fan Static Pressure (FSP). The Fan Total Pressure includes the velocity pressure loss of the fan to atmosphere. The value provided by the simulation (FTP) considers evasé and discharge area size, but is theoretical, and does not include shock or frictional losses between the fan collar and the fan discharge outlet. As a result, for an actual fan installation, additional FTP beyond the simulated result may be required to achieve the simulated results. As every fan and installation is different, it is best to discuss this with your fan manufactures in pressure critical installations.

Fan Power The fan power is calculated on Fan Total Pressure (FTP) and represents the power the fan motor is applying to the fan blades to generate the pressure and flow through the fan. The fan shaft (absorbed) power is calculate from the fan power curve. If a power curve has not been set for the fan, the fan total efficiency curve is used in conjunction with fan total pressure and volume flow, to calculate shaft power. If *this* is unavailable, the default fan efficiency is used.

Fan Electrical power is the estimated electrical power drawn by the fan motor. It is calculated from the Fan shaft power factored up by the motor efficiency factor set in the Settings menu.

Fan Cost The annual cost figure is derived from the power cost set in the Setting Menus for a fan operating at this duty point continuously for a full year.

Fix Present

Fix flows or pressures are often entered where a specific fan is not available or needs to be calculated. The fixed flow information in particular is useful for identifying duty points for fan pressure at a specific volume. This point can then be used to specify and source a suitable fan with a curve that can matches the pressure and flow.

Fixed Duty Point A fixed flow will show a required fan static and total pressure for an equivalent fan in the airway. This is similar to a duty point for a fan. Fixed flows are calculated as a Fan Static Pressure and a Fan Total Pressure and take into account airway or fan discharge area size. For intake fan or underground booster fans, only the Fix Total Pressure (FTP) should be considered in specifying a fan.

For a Surface Exhaust Fan, the Fix Static Pressure is arguably the critical pressure value, as the velocity portion of the Fix Total Pressure is lost to atmosphere. As with fan, the Fix Static Pressure is equivalent to the Total Pressure across the underground mine network, and the Fix Total Pressure includes the discharge velocity pressure but **EXCLUDES** any shock or frictional losses between collar and discharge. If an operating point for a surface exhaust fan is being simulated and potential fan evasé size is not known at the time, it is recommended that the FSP duty point value be used for specifying a duty.

For accurate and more detailed duty point analysis, the Total Pressure method should be chosen in the Settings > Airflow simulation options, which forces the program to consider all velocity pressure losses to the surface across a mine network.

Required Power The power value will utilise the default efficiency set in the Settings Menu and describe a minimum motor size (shaft power) for the required fixed flow, and estimated power (electrical) consumption for the fixed flow.

Annual Fix Cost The annual cost figure is derived from the power cost per kilowatt hour set in the Setting Menus for a fixed flow or pressure operating at the duty point continuously for a full year.

8.5.2 Pressure Information

Describes various pressure conditions at either end of the airway.

Relative Pressures The pressure at either end of the airway in relative to the equivalent surface pressure at the same elevation. Negative values indicate the relative pressure is lower than the surface pressure, while positive values indicate the opposite. Relative pressure in different parts of the mine can help show which direction air would flow if they joined. Air will always flow from higher relative pressures to lower relative pressures if a path is available.

> Note : As the relative pressure describes airway pressure at an equivalent elevation, if effectively ignores elevation and barometric effects of depths.

Barometric Pressures Describes the calculated barometric pressure at the start and end of an airway. Barometric pressure increases with elevation depth, and is in addition to any pressure influences on the network by fans or other pressure sources. Barometric pressures and the resulting densities are an important factors in fan performance and heat simulation.

Pressure Loss Describes the frictional pressure losses along an airway, plus pressure additions due to fans or other pressure sources. A negative value indicates frictional pressure drops are larger that pressure additions to an airway. A positive value indicates pressure additions from fans or fixes have more than overcome frictional losses and contribute to system pressure increases elsewhere in the network.

8.5.3 Heat Data

Heat data shows various air conditions derived from heat simulation.

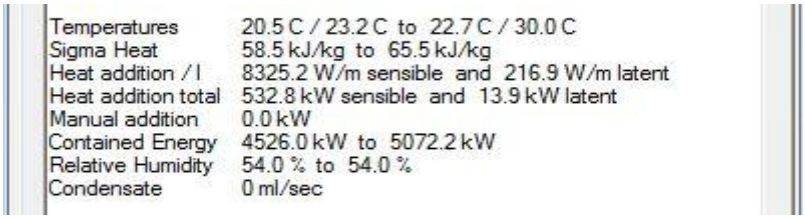

Temperatures 20.5 C / 23.2 C to 22.7 C / 30.0 C
Sigma Heat 58.5 kJ/kg to 65.5 kJ/kg
Heat addition / l 8325.2 W/m sensible and 216.9 W/m latent
Heat addition total 532.8 kW sensible and 13.9 kW latent
Manual addition 0.0 kW
Contained Energy 4526.0 kW to 5072.2 kW
Relative Humidity 54.0 % to 54.0 %
Condensate 0 ml/sec

Figure 8-17 Heat Data

Temperatures Wet bulb and dry bulb temperatures at the start and end of the airway

Sigma Heat The Sigma Heat content of the air at the start and end of the airway. This value describes the heat content of air per unit weight, and is therefore independent of air or mass flow rates.

Heat Addition / l The amount of sensible and latent heat added to the airflow per unit length. The heat may be sourced from rock strata, auto compression or a heat or refrigeration input value.

Heat additions total The total amount of sensible and latent heat added for the full airway length.

Manual addition The amount of heat added by the user in the form of sensible, latent or diesel heat input.

Contained energy The amount of sigma heat present in airflow, multiplied by the mass flow of the air through the airway. The difference in these values should be equivalent to the total heat addition to the airway.

Relative Humidity The moisture content of the air relative to the total saturation potential of the air at the current temperature and pressure conditions.

Condensate The volume flow of moisture condensation from airflow due to environmental conditions changes which result in air temperatures or pressures falling below the saturation point of air. This normally results from a refrigeration source chilling air below the dew point temperature, or a reduction in barometric pressure (from air travelling up a shaft for example) reducing air moisture carrying capacity.

8.6 Notes

The Notes Tab allows detailed information to be recorded for any airway.

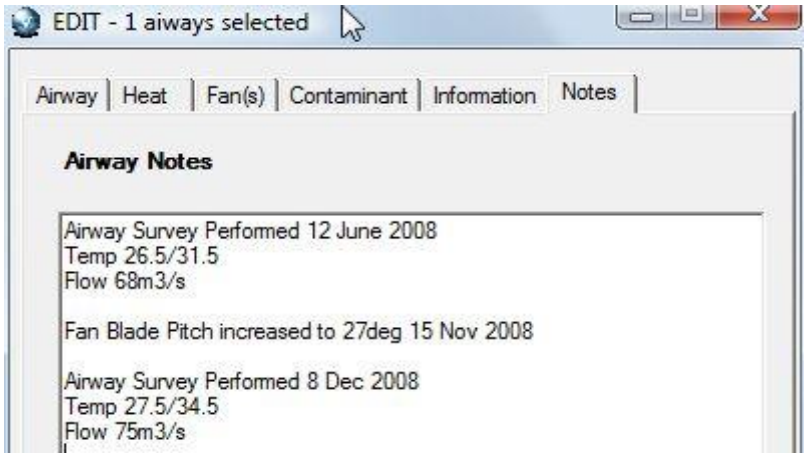


Figure 8-18 Recording sheet for entering general airway information

Notes may include specific network setup information, or may consist of ventilation survey results of airflow, temperatures or gas levels for actual underground ventilation conditions. Such information could be used to help validate simulated networks, or could provide a useful ventilation recording tool to demonstrate ventilation conditions underground over a period of time, or provide a Statutory record of ventilation information.

Chapter 9

Chapter 9 Heat Assistant

The heat assistant helps in calculating thermodynamic inputs into the ventilation network. The calculator can quickly establish required cooling, heating or moisture loads, which can then be accepted in the network.

The assistant is also useful for 'pre-conditioning' airflow to a required temperature and humidity to more closely simulate observed conditions underground.

Pressing Accept after any calculate will insert the values into the network airway for future simulation. This will overwrite any existing values within the airway.

Warning : The assistant calculate estimates only. The assistant utilises an iterative technique, with initial values sourced from the airway currently being edited. The initial values can be changed as desired. Because the simulation process utilises a more detailed, multiple pass approach, taking into consideration surrounding airways and rock heat transfer into the airway, the resulting estimates from the assistant may not always equal the values ultimately calculated in the simulator.

The assistant contains five (5) tabs.

9.1.1 Airflow # 1

Calculates the required heat loads to condition air from one state to another. The values are returned as sensible and latent heat estimates.

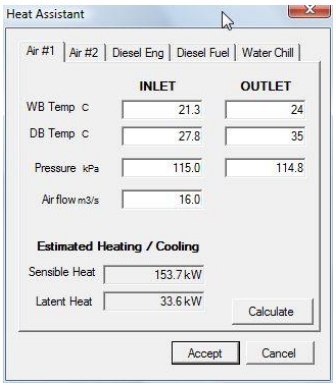


Figure 9-1 Airflow Calculator # 1

Values returned for sensible heat are generally (+ve) for heating or (-ve) for cooling. Values returned for latent heat are generally (+ve) for humidification or (-ve) for de-humidification or drying of air. The word 'generally' has been included as differences in pressure can influence the amount of sensible and latent heat available in the process.

9.1.2 Airflow # 2

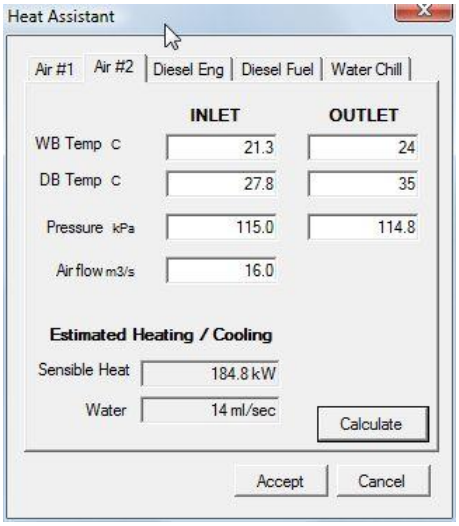


Figure 9-2 Airflow Calculator # 2

Similar to the Airflow #1 calculator, this calculates the required heat loads to condition air from one state to another, but instead returns values as sensible and moisture flow estimates. This may be useful for calculating moisture being evaporated from underground processes such as decline dust suppression sprays, or evaporative cooling chambers.

9.1.3 Diesel Engine

Diesel engine heat loads can be more accurately calculated by considering the environment and utilisation of the diesel engine within the network. The diesel engine calculator assists with this. The output of the calculator is return as an averaged diesel engine output. The corresponding sensible and latent heats are also provided as a reference, however are not transferred to the network as Ventsim Visual™ automatically calculates these values in the network from the diesel power value.

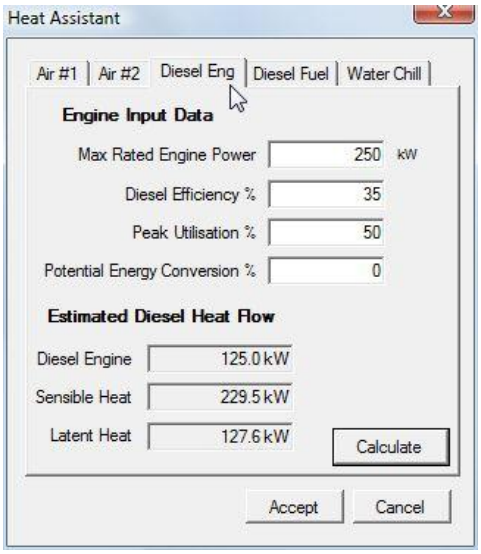


Figure 9-3 Diesel Heat Estimator

Diesel Efficiency

The percentage of diesel calorific energy converted into mechanical energy. This diesel efficiency is an estimated value for a typical diesel engine and generally should not be changed unless specifically known for a type of engine or particular type of fuel. The value dictates the amount of heat placed in a network per unit of engine power used.

For example a 200kW rated diesel engine, will consume nearly 600kW in diesel fuel energy, initially rejecting 400kW of waste heat through engine friction and exhaust. In most cases, the remaining 200kW of mechanical power will also be converted to heat through further friction losses, except where the mechanical power may be partially passed to other energy absorbing processes (such as water or transfer of rock uphill). If required, this can be accounted for under the **potential energy conversion item**.

Peak Utilization Diesel engines underground rarely operate at full power 100% of the time. It is important to consider the actual weighted percentage of time engines are operated at full power to gain the true heat input into the mine network.

For example, a load haul dump unit (LHD) operates continuously, but uses only full power (100%) while loading buckets and hauling up a ramp for 15 minutes per hour, operates at 50% maximum power tramming horizontally or downhill for 30 minutes per hour, and idles at 10% maximum power for the remaining 15 minutes per hour

$$\frac{\left(15 \times 100\% + 30 \times 50\% + 15 \times 10\%\right)}{60}$$

=52.5% peak utilisation

Potential Energy Converson In some processes, diesel mechanical engine power can be converted into other useful energies. For example a truck hauling rock up a decline will impart a portion of its mechanical energy into the potential energy difference of the change in elevation of the hauled rock. This can be calculated as a percentage of the mechanical output of the diesel engine, and will reduce the amount of heat input into the network. In most cases, this will only be a small fraction of the diesel engine power, and in many cases can be ignored.

9.1.4 Diesel Fuel

The diesel fuel calculator provides an alternative way to calculate engine power within a ventilation network, overcoming the need to estimate engine utilisation. It calculates diesel engine power by using the calorific heat value of fuel, and back calculating engine power using 35% diesel efficiency.

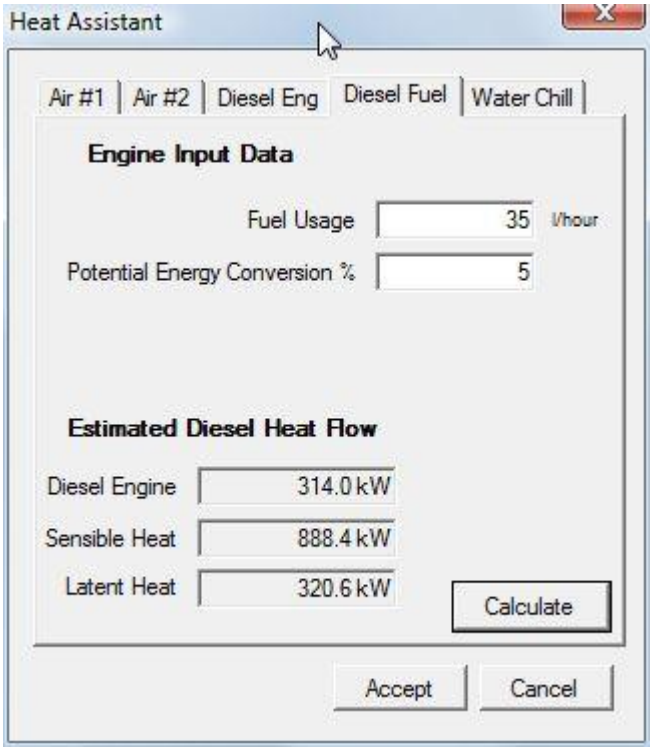


Figure 9-4 Diesel Fuel Consumption Assistant

By entering the average fuel usage of a diesel engine, Ventsim Visual™ can calculate the equivalent average engine output for use in the network. If this value is derived from actual engine diesel fuel usage of a particular unit in operation (many modern machines automatically record average fuel flow), this therefore already includes time the machine is not operating at full capacity.

As with the previous tab, a portion of the diesel engine power can be included as potential energy to another process. This reduces the effective diesel heat input into the network.

9.1.5 Water Flow

The water flow calculator estimates the amount of heat imparted into a network from water flow source.

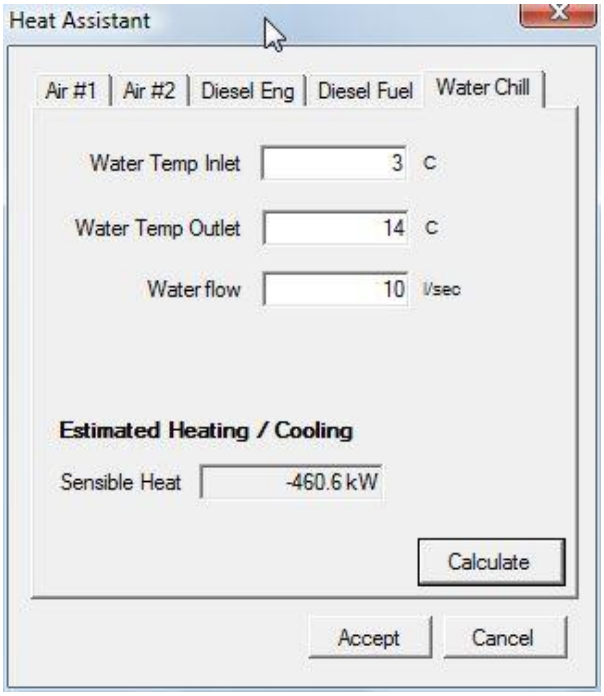


Figure 9-5 Heat Assistant Screen

The Water Chill tab may be useful for estimating;

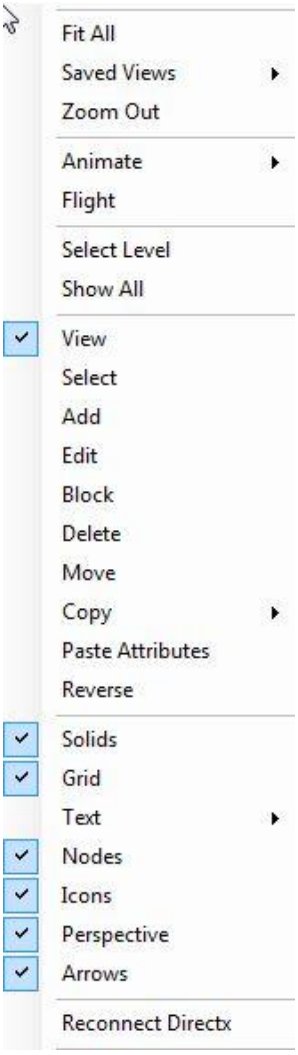
How much cooling power a cooling tower or spray chamber is producing from a refrigeration water source.. Ventsim Visual™ will calculate how much cooling is being generated from the flow and temperature change of the water into the airflow.

How much heat a geothermal water source may be putting into a network. To calculate the heat input, simply input the average water temperature entering the mine (from a rock fissures for example), and enter the average water temperature and flow exiting the mine (at a pump station discharge for example). Ventsim Visual™ will calculate how much heat is being lost from the water and ultimately enters the airflow.

Chapter 10

Chapter 10 Popup Context Menu

The popup menu, activated at any time by a Right Mouse Click, provides a useful collection of commonly used function. While most of the functions are also available from the toolbar or top menu, the popup feature can save considerable time as the mouse cursor is not required to return to the top of the page when a new function is selected.



10.1.1 Fit All

Scale view window, so all network graphics fit on the screen.

10.1.2 Saved Views

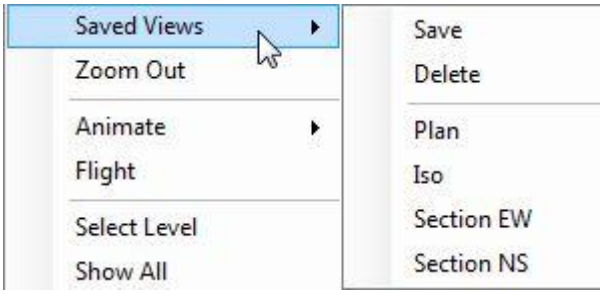


Figure 10-1 Save Views

Save **Saves the current view for recall at a later date.**

Delete **Deletes the current view from the menu list**

Plan, Iso, SectionEW, SectionNS **Pre-saved views** which will orientate the screen in the selected direction

10.1.3 Zoom Out

Increases the distance away from the point of focus by a factor of two.

10.1.4 Animate

Animates flows arrows around an airway network. Flows can remain animated while other functions are performed.

X1 **Animate flows in true real time**. Arrows travel at the same scale speed as calculated air velocity.

X5 **Arrows travel at five (5) times** the scale speed of calculated air velocity.

X10 **Arrows travel at ten (10) times** the scale speed of calculated air velocity.

STOP **Stops flow animation.** Flow animation in large network can consume significant processing power and slow network response and rotation. It is recommended flow animation be turned off when not needed on larger networks.

10.1.5 Flight

Enters a flight mode, which allows the user to freely 'fly' around the model in three dimensions. While this may be of dubious value, it is possible to follow and track specific flow directions by following airflow arrows around the model. To control the flight system, simply move the mouse similar to an aircraft flight stick.

Mouse Controls

Mouse Up Pitch down

Mouse Down Pitch up

Mouse Left and Right Yaw (turn) left or right

Mouse Scroll Button Control Speed Forward and Reverse

Escape Key Exit flight mode

10.1.6 Select Level

Selects one or more levels or elevations for separate display on screen. This can isolate a specific range of airways for display, which can clarify display on screen in complex networks. The function works independently of the levels specified in the level (elevation) database. Any elevation or range of elevations can be selected at any time.

The elevation range is selected by LEFT mouse clicking one or more airways on the screen, and RIGHT mouse clicking to commit and activate the selection. As airways are clicked, the elevation range selected will turn YELLOW. To select a larger area or range of elevations, draw a fence (by holding the left mouse button and dragging the box) around the airways within the desired elevation.

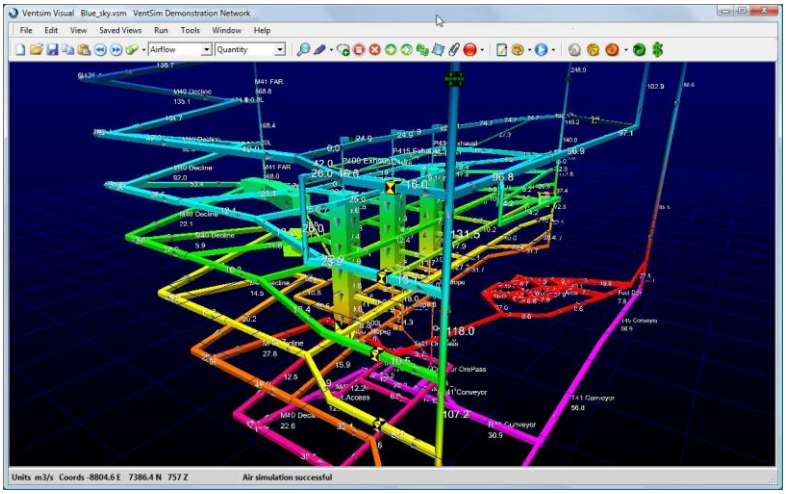


Figure 10-2 Network example before level selection

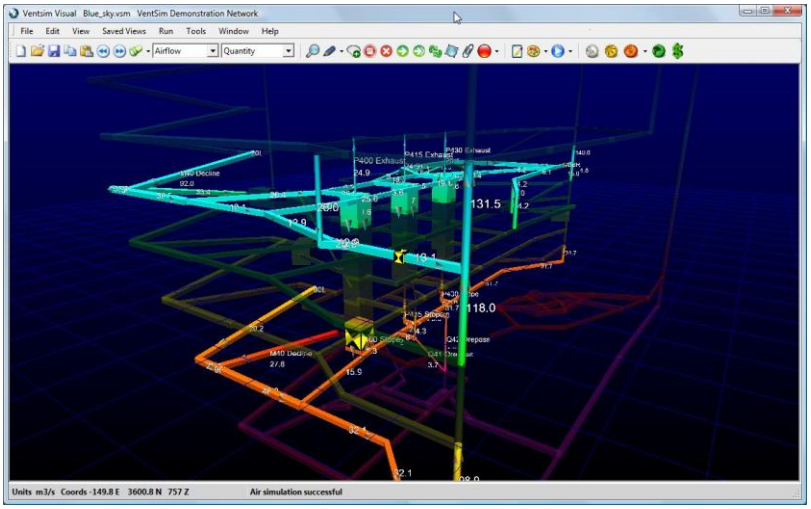


Figure 10-3 Network example after level selection

> Hint : Ventsim Visual™ initially defaults to displaying a 10 metre window range around the selected levels. Airways outside of this range will not be displayed, or will be made transparent. The range can be changed from the **Settings menu**.

10.1.7 Show All — **Display all elevation ranges**. This function will reset any levels selected from the previous function.

10.1.8 View — **Enter the view mode.** See toolbar view for more information.

10.1.9 Select — **Enter the selection mode.** Airways selected can be deleted, edited, moved or copied. See toolbar selection for more information.

10.1.10 Add — **Enter the airway construction mode.** Airways can be drawn by dragging the mouse or edited by clicking the mouse. See toolbar add for more information.

10.1.11 Edit — **Enter the airway edit mode**. Airways clicked or fenced can be edited in the Edit box. See toolbar edit for more information.

10.1.12 Block — **Enter the airway block mode**. Airways clicked can be blocked or unblocked to prevent or allow airflow. See toolbar block for more information.

10.1.13 Delete — **Enter the airway delete mode.** Airway clicked, or fence selected and clicked are deleted from the network. See toolbar delete for more information.

10.1.14 Move — **Enter the airway move mode.** Airways clicked can be moved via coordinates. Airways dragged can be moved with the mouse. See toolbar move for more information.

10.1.15 Copy Airway — **Enter the airway copy mode.** Airways clicked can be copied via coordinate entry. Airways dragged can be copied with the mouse. See toolbar copy for more information.

10.1.16 Copy Attributes — **Enter the copy attributes mode**, which copies selected attributes from one airway in preparation for pasting the attributes on another airway.

10.1.17 Paste Attributes

Enter the paste attributes mode, which pastes copied attributes onto one or more airways. Click or fence the desired airways to apply the attributes. Further information is available at Menu-Edit-Copy Paste Attributes.

10.1.18 Reverse

Enter the reverse airway mode. Airways clicked are reversed along with any fixed flows, pressures or fans. See toolbar reverse for further information.

10.1.19 Solids

Select solid or wireframe graphics. Wireframe graphics may be more suitable for cluttered display, or where solid graphics tend to become too small or narrow with distance. Wireframe airways are always shown with the same intensity, regardless of distance from the viewer.

10.1.20 Grid

Display the coordinate grid. Grids coordinates and spacing can be adjusted in the Settings menu.

10.1.21 Text

Selects text data to display

10.1.22 Node

Display airway junctions as spheres. Nodes display where airways are joined and can assist with construction and editing of airways.

10.1.23 Icons

Displays icons on airways associated with specific airway attributes such as fans, resistances, fixed flows and pressures. Airways with multiple attributes are displayed with icons side by side.

10.1.24 Perspective

Displays the model with or without perspective. Ventsim Visual™ is optimised to work with perspective driven display, however there may be specific occasions where perspective is not desirable.

10.1.25 Arrows

Displays airflow directions arrows. The arrow can be animated to show airflow speed. See toolbar – animation for further information.

10.1.26 References

Displays referenced graphics that have been imported via a DXF file. This function turns all referenced graphics on or off. To individually turn the graphics on or off, use the Reference Manager under the File menu.

10.1.27 Reconnect DirectX

Connects the Windows operating system to the graphics hardware device. The software link may occasionally become disconnected or corrupted, resulting in a blank display. Reconnect the DirectX interface will reset the graphics software to hardware link and re-establish the display.

Chapter

11

Chapter 11 Building a Network

A ventilation network must have a number of key components to successfully run.

Simple Rules for Constructing a Network

- *Keep in mind a number of simple rules must be followed for a successful network.*
- *All airways in a network must be connected at both ends to another airway, unless connected to the surface or 'blanked' off as an open end.*
- *A network must have a device(s) to produce pressure within the network and induce airflow. Pressure producing methods use in Ventsim Visual™ includes placing fans or a fixed airflow or pressure within an airway. Any fixed flow in an airway must not restrict another fixed flow elsewhere in a network.*

11.1 Airways

A ventilation network must have a framework of connected airways or branches. For airflow to successfully travel along an airway, each airway must have a connecting airway at the entry and exit. Airways with no connection at either end will not carry airflow unless connected to the surface.

11.1.1 Network Types

A ventilation network can be developed as either a **closed** or **open network.**

Closed Network

A closed network does not have any airways connecting to the surface. While this would be unusual for a real mine, for diagnostic purposes it is possible to build and simulate an entirely closed network, which continually circulates air around the networked airways. To construct a closed network, simply connect and loop all airways so that they form a continuous path and all airway ends are connected to at least one other. Because a closed system is entirely self contained, pressures and energies placed within the network to distribute flows are entirely consumed by the airways in the network. No ventilation energy is lost to outside sources.

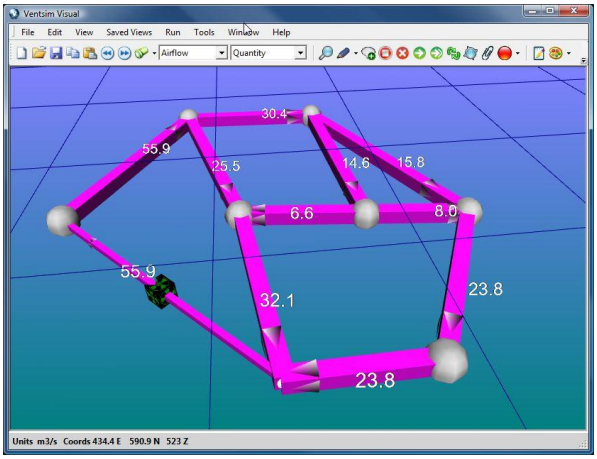


Figure 11-1 Example of a Closed Network

Open Network An open network has at least two airways which connect to the surface, at least one of which is an intake airway, and another which is an exhaust airway. Most (if not all) mines will be established as open networks. Airflow which exits an exhaust airway, in no way influences the pressure (or temperature) of the airflow which enters an intake airway. Airflow velocity pressures and energies lost from an exhaust airway are assumed lost to the network system. To link any airway to the surface, simply use the Connect to Surface function under the Edit Form.

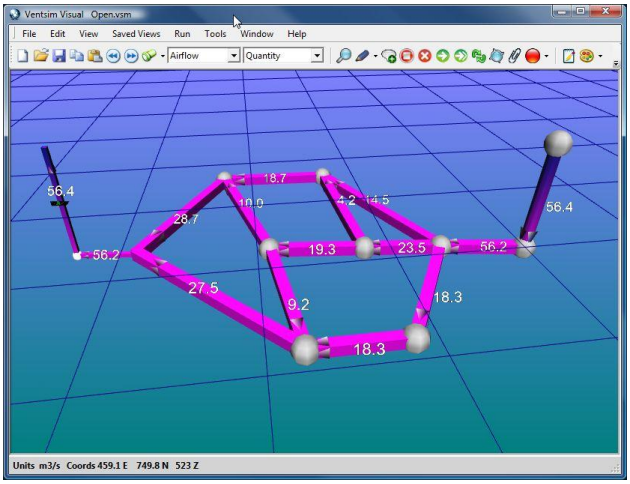


Figure 11-2 Example of an Open Network

11.1.2 Airway Construction Methods

- Airways can be constructed in a number of ways.
- Manually draw scaled airways using the toolbar functions
- Manually draw schematic airways using the toolbar functions
- Import airway data from a formatted spreadsheet using the TXT import function

- Import airway data from a DXF graphics file, exported from a CAD or mine planning package.

Manual Scaled Construction

To manually construct airways, simply use the construction tools from the toolbar.

Airways can be drawn freehand on the screen with the mouse, using the coordinates displayed in the status bar to guide the airway location. Additionally, coordinates for airways can be entered manually using the coordinate entry function or by simply clicking on an airway end while in the draw mode.

This method is generally suitable for small networks (less than several hundred airway segments). Airway networks are generally fairly tolerant of misaligned or slightly misplaced airways, providing approximate airway lengths are close to reality. In many cases, to assist with clarity, airways can be deliberately moved aside, and a fixed length function used to correct airway length to actual lengths.

Manual Schematic Construction

In some cases, a network schematic can be constructed to simulate a network. A network schematic may look nothing like a real mine, but simply represent airways by a series of conveniently located two dimensional lines. Correct airway lengths can be entered by fixing the length under the Edit From.

Warning: Schematic Networks, although convenient in simplifying mine airway networks, have major restrictions which can affect their functionality in Ventsim Visual. Ventsim Visual™ uses true airway locations to calculate changes in air density and heat properties of rock and airflow, and as such, schematic networks are largely unsuitable for Ventsim Visual™ Advanced networks simulate deep mines with compressibility effects or for heat simulation.

Spreadsheet Text Import

Where a list of airway coordinates and sizes may be available (from a database or another ventilation program for example), these can be directly imported into Ventsim Visual™ using the File Open Text Function. Data to be imported must meet a specific TAB delimited data format. This format can be loaded and saved by most office application software such as Microsoft Excel or Word.. This format can be viewed by saving any existing network file as a TXT file format under the save menu.

DXF Graphics Import

For large networks, that need to be built to scale from existing mine workings or designs, the best method is to import DXF data (AutoCAD Drawing Exchange Format), and allow Ventsim Visual™ to construct a network from the imported data lines. The DXF import function can be activated from the File Import menu.

11.1.3 Import DXF Graphics Line Data

STEP 1 – Create and Import a DXF file into Ventsim Visual

This method relies on passing line or string graphics data from a CAD or Mine Planning package to Ventsim Visual. The data may simply be the centre lines of surveyed mine floors or mine designs. To allow Ventsim Visual™ to efficiently use this data without excessive post import editing, the following criteria should be considered.

Only import the minimum data required. Excessive detail or headings which do not form part of the ventilation network should not be imported if possible. In many cases, is may be quicker and more accurate to construct a skeleton ventilation network consisting of interconnected lines within the Mine Planning or CAD package, before import into Ventsim Visual. The skeleton lines should simply trace over existing mine workings or designs.

Try to ensure the lines join into each other, so Ventsim Visual™ knows they are junctions through which air can flow. Lines that simply cross each other without a junction, or which terminate close to each other but not join, will not carry airflow, and may result in a no exit/entry error in Ventsim which will need to be corrected in Ventsim.

When importing data, the lines can be converted to airways during the import process (by selected the option "**Convert to airways'**), or selectively after importing using the **DRAW > CONVERT** button to click or fence which lines are to be converted. The second option has the advantage of overlaying the updated DXF files with new development over the existing Ventsim airways, and selectively choosing where to update the Ventsim model.

Hint : To efficiently add DXF data to Ventsim Visual, keep a 'layer', 'object' or 'file' within your Mine Planning or CAD package dedicated to Ventsim Visual™ data, As new airways or designs become available, simply export the additions as separate DXF files, and import them into Ventsim Visual™ to add to the existing network.

Warning : Three dimensional solids (such as survey mine solids) will import into Ventsim Visual, but cannot directly be converted to airway. They can however be used as a guide to manually draw and construct new airways in the network

A number of options exist when imported a DXF file into Ventsim Visual

STEP 2 – Modifying and Validating Import Data

Once imported into Ventsim Visual, the program will assign default airways sizes and shapes to all the imported airways. Ensure you have default sizes and shapes set in the Settings menu that will approximate the typical sizes that are imported. This will prevent having to re-edit of ALL of the airway sizes and shapes (although this can still be quickly done using the **group edit** command)

Checking for Errors

To quickly sort and validate (check) the imported airways, click on airflow simulation. While the network is unlikely to correctly simulate, this function will check the airways for duplicates and unconnected airway ends, which will speed up the process of establishing a working network.

In most cases, errors will result from airways not exactly joined into other airways, resulting in no exit or entry errors. To correct these errors, a number of tools are provided in the TOOLS > FILTER OPTIONS menu, to bind and connect these 'loose' nodes, and find duplicated airways. Alternatively, simply use the **toolbar move** function to move the airway end onto the other junctions ends. If this is done correctly, moving the node will then result in all airway ends moving simultaneously.

Under Tools > Utilities

- FILTERING TOOLS
    - BINDING : **Bind Nodes** (use a value up to 4-5m or more to bind ends that are close to each other). Bind Junctions (Binds loose nodes that are close to a passing airway which has no corresponding node or junction). **Bind Intercepts** (find and/or join airways that cross each other, but have no joining nodes)

- SIMPLIFY (remove a lot of the small rubbish and unnecessary detail)
- DUPLICATES (find and/or remove any duplicated or overlapping airways)

- SELECT THE AIRWAYS THAT SHOULD CONNECT TO SURFACE AND SET THEM IN THE EDIT BOX
- SELECT LOOSE ENDS (BOTH) and DELETE if not required for simulation (deletes airways floating by themselves). This option is available in the TOOLS menu, or directly from the Select function in the EDIT box.
- SELECT LOOSE ENDS (ONE) and EDIT and either DELETE or set to ALLOW OPEN END (allows dead end headings such as truck bays). This option is available in the TOOLS menu, or directly from the Select function in the EDIT box.

The above steps should sort out most of the erroneous airways. The next step is to sort out a uniform direction for all airways. Airways which do not uniformly face the same direction along a connected string of airways will result in a no entry/exit warning, preventing flow. This can be corrected manually by reversing individual airways with the REVERSE button, or by using a differential pressure method described below to assist Ventsim to work out the correct direction.

Differential pressure method

To correctly align airways in a uniform direction, Ventsim Visual needs an indication at which way air may flow. This does not need to be a final correct direction. To establish a 'hint', a pressure differential needs to be created somewhere in the mine network. The easiest way to accomplish this is to EDIT A SURFACE CONNECTION and FIX a flow (eg 100) - this will create an arbitrary pressure and flow which helps reverse any airways facing the wrong direction. Simulating the network will align all connected airways. Airways which are not aligned are probably not connected properly to the network, and should be closely examined for corrected node joins.

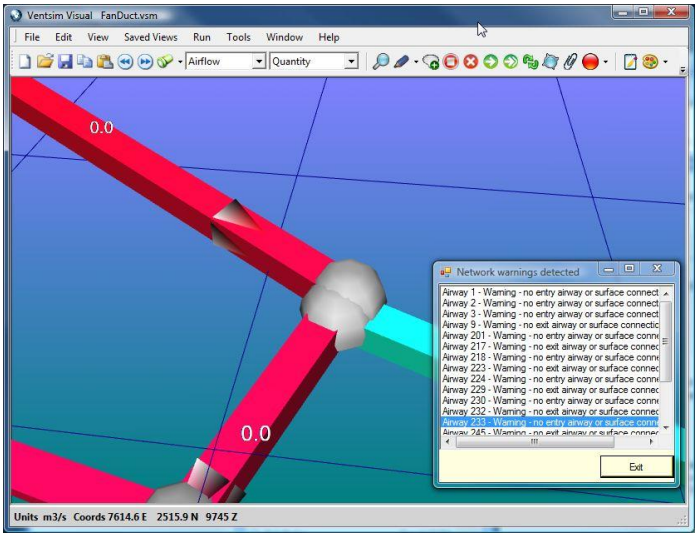


Figure 11-3 Example of import error after simulation resulting from misaligned ends or unjoined nodes

11.1.4 Simplifying Data

In many case, importing a DXF files directly from a mine planning will create an overly detailed network file, which will slow down the system graphics and simulation, resulting in a more unwieldy network. For example, a nice smoothly rounded decline airway which produces many airway segments is simply not required for accurate ventilation simulation and in most case can be designed with less segments and detail. The Tools > Filtering > Simplify function in Ventsim Visual, will sort through a network, identifying unnecessary detail, which can be removed without adversely affecting simulation.

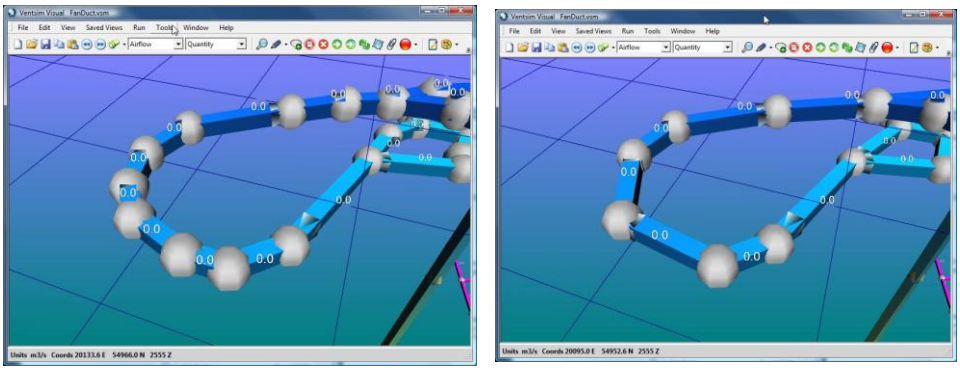


Figure 11-4 Example show the effect of the Simplify Function to reduce airway data

Alternatively, airways can be manually simplified by using the toolbar delete function to remove node junctions between airways.

Hint: If imported data is to be simplified, and joined to an existing network, it may be best to keep the imported data in a separate file, until it has been edited, validated and simplified to a point where it can be placed directly into the existing network. The file can then simply be merged in with the existing network file.

11.1.5 Ventilation Ducting and Blind Headings

In most mines, a number of blind or 'dead end' headings will exist. By network definition, a blind heading cannot carry airflow, as it does not have a continuous path of airways leading to and from each end. In many real cases however, these headings are effectively ventilated by duct, and often need to be simulated within a network, if only for the fact that development fans blowing into ventilation duct are moving air from one part of the mine to another, or that the geothermal heat and moisture generate by these headings needs to be included in the mine heat balance.

To satisfy a network requirement for a continuous air pathway, ventilation duct needs to be included as a separate airway. For clarification, this airway is best placed outside of the mined airway, and sized according to true ventilation duct size. The ventilation duct airway will carry air to the blind heading face. Te blind heading airways will carry airflow back to a network junction, and then join any other airflow beyond the blind heading.

Hint : Make ventilation duct airways into another airway type under the **Edit Form**., and specify the **air type** as a ventilation duct. Airway type number #5 is yellow if

colour, and can be renamed to a ventilation duct, to clearly show the colour differentiation when **air type** is selected from the Colour Manager. In addition, the vent duct airway could be placed on a separate layer, so the vent duct in the view could be turned off or on.

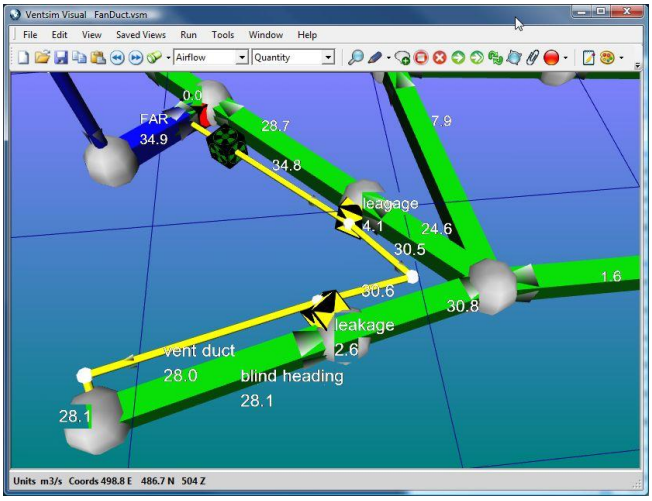


Figure 11-5 Example showing ventilation duct into blind heading. Note the two leakage paths included to 'simulate' vent duct leakage

Warning

Ventsim Visual™ **will not** simulate the leakage of air along a ventilation duct. As a result, fan pressures predicted for ventilation duct will most likely be higher than in real life, as resistance and pressure drop is assumed for the full airflow along the entire length of duct.

For nearly all duct, a leakage factor will exist which will release air under pressure along the entire length of ducted airway. As a result, the volume entering the duct will be more than the volume exiting the duct, with the difference in airflow released into the airway carrying the duct. The leakage factor is normally much higher for flexible duct compared to solid duct, and varies substantially due to the condition of the duct at the time.

If duct leakage is critical to your simulation, it is recommended empirical measurements or third party software be used to predict air loss along a duct. Air loss in Ventsim Visual™ *could* be simulated by building high resistance leakage paths from the ventilation duct to the adjacent airway.

Interconnecting Mine Airways

In some mines, airways may connect to other parts of a mine which are not simulated or included in the network. The airflow to or from these other parts must be included into the local network. To include airflows to areas not simulated or included in the current network, simply run a single airway off the main network, assign a Connect to Surface attribute under the Edit Form., and then enter a fixed flow to simulate airflow to or from the area. Ensure the direction of the airway is correct.

11.2 Pressurising a Network

To produce pressure within a network to motivate airflow, the following three methods can be used. Without network pressures, airflow will simply remain stagnant.

> In Ventsim Visual™ Advanced, a fourth method consisting of natural ventilation pressures can also induce flow, although this is entirely derived from heat and density air changes throughout the mine. It is possible to build a ventilation network with airflow driven entirely by geothermal heat or evaporative cooling, however the simulation results can sometimes be unreliable due to changing airflow and pressures continuously affecting natural ventilation pressures.

11.2.1 Fans

To construct a fan database from an existing fan manufactures curve, follow the steps below.

1. Identify the type of fan pressure curve used, the fan configuration and exit diameter, and the air density the fan curve is established at.

2. Divide the curve into ten (10) points. Do not include the STALL region of the curve in the fan database. Entering the stall region of a fan may result in an unstable network simulation at it oscillates between the two pressure and volume flow states..

3. Note that less than ten (10) points can be entered if desired, however this will increase interpolation errors between points resulting in a less accurate simulation.

4. Enter the curve points and fan information in the Fan Database edit form.

5. To utilise the fan within the network, ensure the Fan Total Pressure method is selected in the Settings, and use the Edit Box to place a fan within an airway.

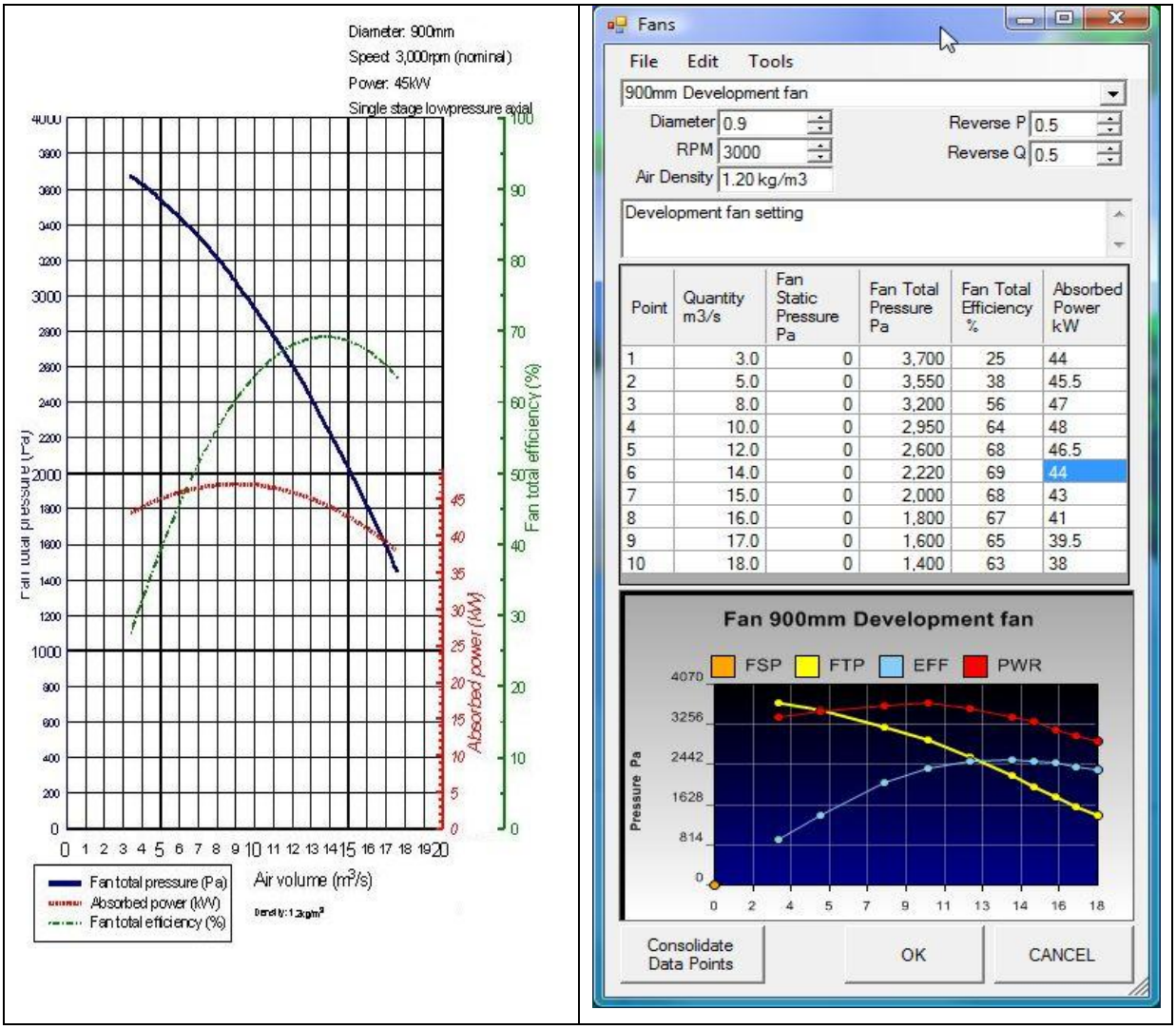


Figure 11-6 Manufacturers Fan Curve entered into Ventsim Visual

The standard fan curve is defined at a set speed and air density. The fan speed can be adjusted from the Edit Box, while the actual fan operating density is calculated from surface and underground pressures and temperatures. This will alter the default fan database curve within the simulation to produce different flow results.

More information on fans is available from the Tools menu Fan Database function

11.2.2 Fan Selection and Design

Fixed airflows can either be used to simulate the effect of a fan, or for forcing airflow into parts of a network to reproduce observed flows.

In general, unless estimating the requirements for a fan, the use of fixed flows to reproduce observable underground airflow is generally discouraged at it may adversely affect other parts of a network and does not provide a realistic behaviour for changes in underground network systems. In many cases it can mask real problems with the network construction.

A fixed flow will force Ventsim Visual™ to calculate a pressure required to induce flow to the set amount. This pressure can be substantial if the airflow needs to

be pushed through a high resistance. Conversely, the pressure may actually be negative, if the fixed flow forces the airflow to be lower than would otherwise simulate, effectively resulting in the fixed airflow acting as a higher resistance.

> Hint : Ventsim Visual™ limits fixed airflow pressure build up to around 15,000 Pa. Pressures beyond this can result in serious network imbalances and heat build up, and in most cases are likely to be erroneous in nature anyway (for example, an airflow fix may be forcing air through a very high resistance). Ventsim Visual™ will raise a simulation error in this case to warn the user of unacceptable pressure build up. This can normally be easily fixed by finding the restricting airway.

In all cases, the results of a fixed flow can be observed from the Edit Box information function, which describes the pressure and power or resistance required to produce the flow. **This can be directly used to estimate a fan duty point** which would be required to produce the same results. This fix pressure can be equivalent to Fan Static Pressure or Fan Total Pressure, depending on the simulation type and location of fan.

Fan Selection (total pressure method)

Where the Total Pressure method has been chosen in the Settings – Air Simulation menu, the Pressure given for fixed flows will be an estimate of the **Fan Total Pressure (FTP) requirement**. For surface exhaust fans, an estimated **Fan Static Pressure (FSP)** will also be provided. Note that for surface exhaust fans, both the Fan Static and Total Pressure requirement is theoretical only and does not include internal fan losses between the collar and discharge outlet, therefore the estimated Fixed Total pressures are likely to be slightly *underestimated* and the fan manufacturer will need to take this into account when selecting a suitable fan. Also note that the simulated pressures provided will be influenced by the simulated Fan or Airway Discharge diameter (evasé) so ensure this is noted and specified when quoting the duty point summary.

Fan Selection (static or mixed pressure method)

Where the Static Pressure or Mixed method has been chosen (which is the default in networks imported from Ventsim Classic 3.9), the pressure provided will be an estimate of the **Fan Static Pressure (FSP)**. Note that this estimate ignores velocity pressures derived from fan discharge diameters and airway discharge areas, as well as internal fan losses, and is considered to be a less accurate method of estimating fan requirements when compared to the total pressure method.

It is important to note that fixed flows contribute to network power consumption and heat, in much the same way as fans. The fixed power and heat within a network is summarised from the Run Summary menu item.

When calculating power and heat for a fixed airflow, the default fan/fix efficiency from the Settings Menu is used.

More information on fixed airflow and pressure is available from the Edit Box functions.

Fan Air Density

Finally, when specifying a fan duty point, it is important that the air density the fan was simulated in is noted. Fan performance varies substantially in different densities and a fan manufacturers will need to know the required density to the fan curve can be adjusted for the local condition accordingly.

For Ventsim Visual Standard, incompressible air is assumed and the air density remains constant and is specified in the Settings menu. For Ventsim Visual

Advanced, this value varies throughout the mine, and may be significantly different from the surface or standard density value.

The Air Density is specified in the airway, or in the Fan or Fix summary page in the Edit Box.

11.2.3 Fixed Pressure

Fixed pressures work in much the same way as fixed airflows, but instead forces Ventsim Visual™ to calculate a resulting airflow to match the input pressures. As with fixed flows, fixed pressures consume power and produce heat, which again is summarised in the Edit Box information summary, or from the Network Summary menu item.

When calculating power and heat for a fixed pressure, the default fan/fix efficiency from the Settings Menu is used.

More information on fixed airflow and pressure is available from the Edit Box functions.

11.3 Utilizing Layers

Layers are a way to individually layer or identify and view parts of a network separately from other parts of the network. Some examples may include a stope system, an orepass or ventilation raise system, a workshop area, or any other collection of airways. Note that there is no requirement for the user to utilise viewing layers. They are only present to allow easier manipulation and viewing of a network.

Layers work by allowing the user to 'overlay' multiple layers of airways or information on a screen. By doing this, unnecessary detail can be 'turned off' so only airways of interest are viewed.

Layers may be made active or displayed using the Display Manager. Layers names can be changed from the Edit Box, by clicking the button adjacent to the layer name.

11.3.1 Primary Layers

Primary Layers consist of 16 layers. It is intended that the Primary Layers be used for identifying types of airways. For example, Layer 1 could be Primary Shafts, Layer 2 could be Main Airways, Layer 3 - Raises, Layer 4 - Stopes, Layer 5 - Minor Airways etc.

11.3.2 Secondary Layers

Secondary Layers, consist of 64 discreet layers. It is intended that the Secondary Layers be used for isolating parts of a network that could be viewed independently from the rest of the network. As mentioned above, this could include working areas, stope, raises, declines or any other feature of interest.

There is no limitation on the number of airways belonging to a layer, however an airway can belong to only one secondary and one primary layer. Primary layers and secondary layers can be set and viewed independently of each other.

See the DEMO.VSM and BLUE_SKY.VSM examples that come with Ventsim Visual.

Hint : To quickly save and recall a 'layer state' use the Save View function to save and recall views with the Primary and Secondary Layers settings.

11.3.3 Using Layers

The easiest way to use Layers may be to create the network first (all airways will default to Layer 1 of both Primary and Secondary Layers, and then editing individual or group airways to change the layers to the desired number.

Hint : The Edit Box has a function which will select and group all similar airways (for example all round airways with a diameter of 3.0m. This can provide a quick way to group edit and change layers for multiple airways.

New airways constructed will inherit the layer numbers of the airway they are constructed from. If no airway exists, new airways will use the default layers set in the Display Manager.

Chapter

12

Chapter 12 Thermodynamic Simulation

[Ventsim Visual™ Advanced]

Thermodynamic (or heat and moisture) simulation is a complex field of mine ventilation and environmental engineering. A comprehensive understanding of psychrometry as well as practical aspects of heating and refrigeration is recommended before using Ventsim Visual™ to assist with major infrastructure decisions for mine planning and development.

12.1 Application of Refrigeration

The application of refrigeration for deeper or hot underground mines has become a routine requirement as mines push deeper and environmental consideration become more pressing.

In most cases, more than just the refrigeration duty must be considered when place a refrigeration source within a network.

For example a 10MwR refrigeration bulk air cooler plant placed on the surface to deliver chilled air down a fresh air shaft must be placed within the network in a specific way.

12.1.1 What is the location?

Ventsim Visual™ assumes any item placed in an airway is simulated at the icon location. For this reason, placing a bulk air cooler in the middle of a shaft, would assume the bulk air cooler is located half way down a shaft, which would clearly not be the case. This assumption would result in differing air densities and air temperature, than would be the case if placed on surface.

It is recommended that for fans and thermodynamic items, the icon be placed where the simulation is required to be performed, or alternatively a short airway segment (vertical or horizontal) is placed at the top of a shaft airway for the cooling infrastructure. This will force the program to use surface conditions for the device.

12.1.2 What portion of the air is cooled?

Ventsim Visual™ assumes ***all*** airflow within an airway is equally cooled by a refrigeration or heating device. If only part of the airflow is actually cooled (and the other part mixes downstream), because of condensation of the split portion the mixed airflow results may have substantially different psychrometric properties than air that was equally cooled.

While the two airflow cases will report similar heat reduction (consisting of sigma heat and enthalpy flow), the partially chilled airflow case may have the refrigerated portion chilled to much lower temperatures, resulting in an increase in condensation and subsequent removal of moisture. The resulting mixed

stream will then be generally warmer, but dryer with a lower relative humidity, compared to the stream which is evenly chilled.

Whether the installation is on surface or underground, if a cooling device only chills part of the airflow, ensure a separate airway is included to represent this chilled portion. The example below shows the substantial difference in downstream temperatures between the two cases.

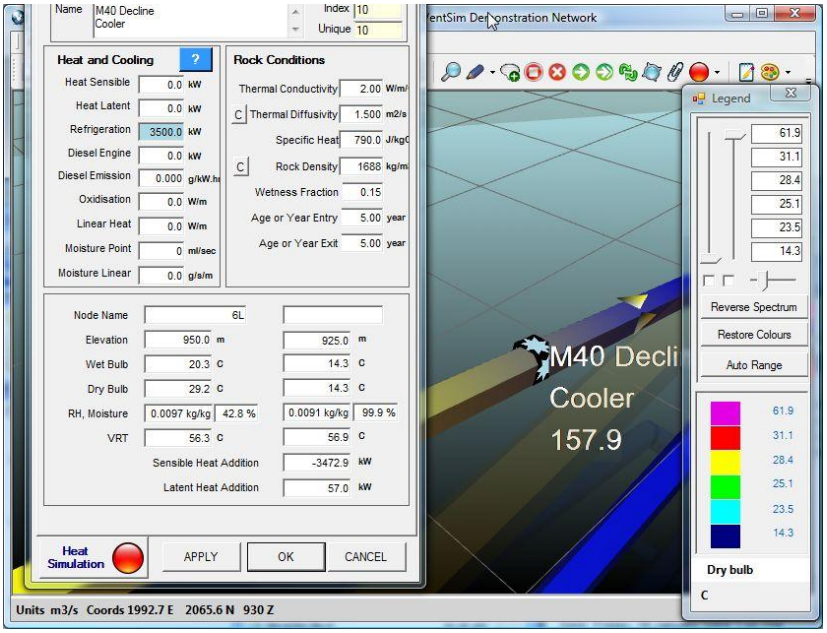


Figure 12-1 Example of an inline cooler chilling ALL airflow

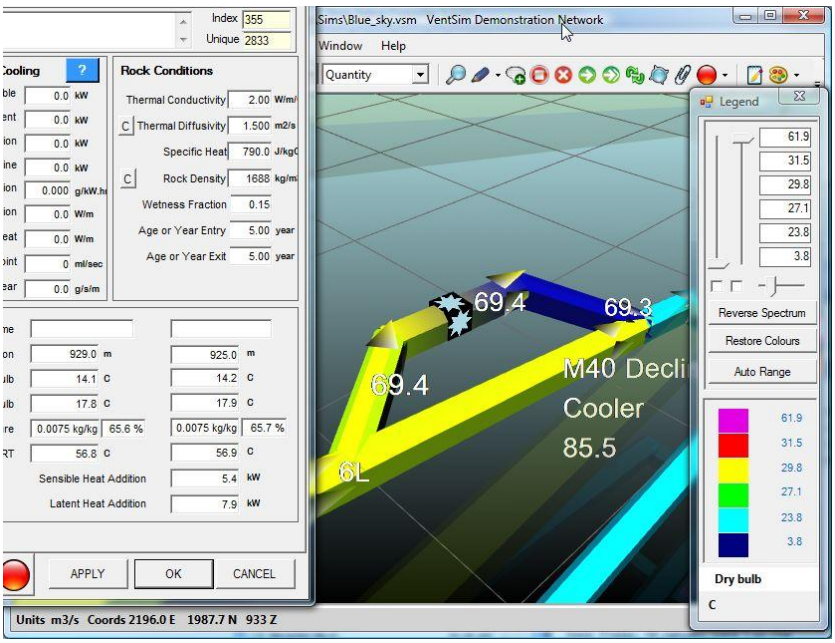


Figure 12-2 Example showing same inline cooler chilling only 40% airflow

Discussion: It is important to note that in both cases, 3500kW of heat has been removed from the air. Downstream from the refrigeration unit, the difference in psychrometric properties of the mixed versus the whole chilled airflows will actually diminish. The dryer warmer air resulting from the mixed case, will actually enhance evaporative cooling from damp or wet airways, resulting in potentially cooler moister air, while the case with the cooler moister flow will enhance geothermal heat transfer from rock surfaces and reduce evaporative cooling.

The resulting air temperatures some distance from the refrigeration source may be very similar.

What type of refrigeration plant is it?

The type of refrigeration plant will have subtle differences on the effect on air temperatures and humidity. A cooling tower versus a spray chamber for example may result in slightly different relative humidity due to the air to moisture contact mechanism, particularly if the dew point temperature of the air is not reached or the air is very dry. Additionally, the presence and location of electrical pumps and equipment required to run the installation may introduce heat back into the airflow for an underground installation, but not a surface installation.

Refrigeration Plant Performance

As Ventsim Visual™ only considers the refrigeration *output* of a plant, the plant performance in achieving this output is largely irrelevant to the simulation. The plant performance however is important in considering the economics and overall effective on the plant per unit of input power, and should be considered separately outside of Ventsim Visual. In addition, fouling and subsequent degradation of refrigeration plants should also be considered when allowing for contingency in sizing a refrigeration plant.

12.2 Application of Heat

Heat application to air from underground sources is in many ways more predictable than refrigeration sources as it does not result in condensation.

Unlike refrigeration the application of similar heat to only a portion of airflow will result in identical mixed temperature regardless of whether a portion or all of the airflow is heated.

The most common user heat input source will be diesel heat or sensible heat.

Warning : Perhaps the biggest mistake in attempting to simulate heat underground, is trying to apply a heat source to an airway carrying small amounts of airflow. While this may be possible in real life due to perhaps only a short time of exposure, because Ventsim Visual™ uses a steady state thermal simulation, the heat is assumed to apply continuously and can result in extremely high air temperatures. As the thermodynamic equations are only optimised for a certain heat range (up to around 70 degrees), excessive heat will produce a simulation error.

12.2.1 Sensible Heat

Sensible heat is the application of heat to the air with no change in moisture content. The situation applies to dry heat sources such as electric motors from fans or pumps, radiating heat from hydraulic or working equipment or frictional heat sources from conveyor belts or crushers.

Note that all ventilation power underground such as fans and fixed flows or pressures are automatically assumed to be sources of heat. They do not need to be entered as separate heat sources.

12.2.2 Diesel Heat

Diesel engine sources underground are internally converted to a mixture of sensible and latent heat for simulation. A diesel engine of a rated power will produce nearly three times the heat of the rated power, assuming no energy is converted to 'useful' work. Ensure when entering diesel heat sources, that only the engine power equivalent is entered, not the engine heat output.

Diesel combustion results in the production of heated exhaust gases and water vapour, which is transferred to the surrounding air. In addition, additional water vapour source from engine cooling systems or the surround environment is added to the air in the form of evaporation. This ratio of diesel fuel to water is set in the Settings Menu, and is considered the same for all diesel heat sources. If separate ratios need to be considered, the sensible and latent heat will need to be entered instead of a single diesel heat figure.

12.2.3 Latent Heat

Perhaps the biggest source of confusion in applying underground heat is the application of latent heat. In general, latent heat, which is essentially adding heat to the air in the form of water vapour, should rarely need to be considered as a separate user input. While latent heat is internally calculated by Ventsim Visual™ in the application of strata heat and diesel equipment, it rarely needs to be applied directly by the suer. The only exception may be to 'condition' air to a required wet bulb and dry bulb temperature, or in the application of heating to a mine with propane or some other moisture producing fuel source.

12.2.4 Oxidisation

Oxidisation heat is included for completeness, but will rarely be required to be entered into a mine network. For most mines with reasonable ventilation flows, oxidisation will be generally insignificant in overall heat gain. The exception may be in highly reactive ores or where there is very low airflow. While there are formulas to estimate the reactive heat of certain types of ores, it is generally unreasonable to try to calculate this value theoretically due to the variability of oxidising ores. In most cases, oxidisation heat can be estimated from empirical measurements from actual underground areas.

12.2.5 Fan and Fixed Flow Heat

All electrical fans generate heat which is dissipated into the surround airflow. The heat generated is equivalent to the input electrical power, and is dissipated into the airflow through a combination of electrical motor inefficiencies, blade inefficiencies and friction losses. Ventsim Visual automatically includes heat from fans in a network heat simulation, therefore there is no need to include fans as a separate heat source

12.3 Application of Moisture

While Ventsim Visual™ automatically considers moisture derived from wet and damp strata surfaces, direct user moisture application to air from underground sources is unlikely to be commonly used in most networks.

It is important to note that moisture application to air does not alter the heat content of the airflow (providing the moisture added is the same temperature as the airflow). Instead, through the process of evaporative cooling, the dry bulb air temperature is decreased, while air moisture content in the form of water vapour increases, resulting in net zero energy change.

Examples of water addition to airflow may be:

Dust suppression sprays

Evaporative Cooling

Conditioning of air for simulation

12.3.1 Dust Suppression

Dust suppression sprays are often used on dusty roadways, at stope draw points or on conveyor belts or crushers. Water sprays directly increase the water content of air through increased evaporation from fine water particles, as well as wet surfaces around the sprays. In many cases however the uses of sprays is often sporadic and does not represent a steady state flow network. For sporadic sprays, a better solution to applying moisture to the airflow in a dust suppression area may be to increase the wall **wetness fraction** to closer to one (1). This will assume the area remains wet and also proportionately alter moisture addition depending on the airflow quantities in the area.

Caution: The amount of water capable of being applied to airflow will be limited by the amount of airflow in the airway. If too much water is attempted to be applied, the excess will appear as condensate in the simulation.

12.3.2 Evaporative Cooling

Another application for adding moisture to is evaporative cooling, however these are not commonly used in mines unless very dry warm air is present. To simulate evaporative cooling, ideally a water balance should be undertaken to identify water being added to the air from an actual installation. Alternatively, a temperature difference before and after the evaporative cooling chamber will allow Ventsim Visual™ to estimate the water balance in the Edit Box **Heat Assistant.**

12.3.3 Wet Material / Dam / Flooded airways

Water may be picked up via evaporation via any wet material or ponded water. Once again, the problem of directly applying a water flow volume to the air is that evaporation will change depending on the volume flow and velocity of the air. A better alternative to applying water over wet or flooded areas is to increase the **wetness fraction** of the airways.

Chapter

13

Chapter 13 Diesel Particulate Matter Simulation

[Ventsim Visual™ Advanced]

Diesel Particulate Matter (DPM) concentrations are a relatively new concern for underground mining operations. While prolonged exposure to high levels of diesel particulates has long been suspected as having potential to cause health problems, only recently have mining regulators started imposing strict atmospheric limits for underground mines. Ventsim Visual Advanced provides tools to assist in predicting the distribution and concentration of diesel particulates through an underground mine.

13.1 Application of DPM Simulation

Ventsim Visual Advanced uses a relatively simple, steady state, homogenous simulation of diesel particulates, with specified emission amounts from diesel equipment exhaust being mixed uniformly with surrounding airflow and distributed downstream. While real time variations in diesel output and mixing of pollutants at junctions will always be variable, because regulatory limits are normally based on an 8 hour time weight average (TWA) exposure for a person throughout a shift, most of these variations are smoothed out and can be ignored.

Tier Standards

Every diesel engine emits a certain level of pollutants; which include noxious gases and solid particulates. In an attempt to impose restrictions on the amounts of allowable pollutants an engine can emit to atmosphere, regulators in many countries have introduced steadily decreasing pollution limits on new engines, known in North America as the Tier standard. Generally speaking, the higher the Tier rating, the 'cleaner' the engine, although there can still be considerable variation between one engine and the next within a Tier standard. The recently introduced Tier 4 standard is being implemented over the period 2008 – 2015 and demands emissions be reduced by up to 90% lower than previous Tier standards. Engine emission results are tested and approved by the EPA in North America, and many of these test result are available online from the internet.

Composition of Diesel Particulate Matter (PM)

The makeup of quoted diesel engine particular matter PM can vary depending on engine type and fuel used, however a widely accepted ratio range is around 50-60% elemental carbon, 20-30% organic carbons and 15-20% other matter. The two most commonly used standards are the elemental carbon value (EC) and the total carbon value (TC) which is the sum of the elemental and organic carbon components. Current North American guidelines state an elemental to total carbon ratio factor of around 1.3X. Unfortunately, most EPA test results do not state the different particulate composition, so it will be up to the user to determine the resulting composition.

Atmospheric Standards

Rather than introduce emission standards, mining regulators focus on atmospheric levels in mining environments. The atmospheric concentration of a diesel engine emission is a function of the rate and concentration of the exhaust emission, and the amount of diluting airflow around the equipment. By placing an engine size and emission concentration in Ventsim Visual, the program can use simulated airflows to calculate the resulting atmospheric concentration.

Regulators have specified either an 'elemental' carbon limit or a 'total' carbon limit for allowable TWA atmospheric levels of diesel particulates. In North America (2008) a standard of 160ug/m3 Total Carbon (elemental + organic carbon) has been initially imposed, while Australia looks likely to adopt a 100ug/m3 Elemental Carbon limit.

Diesel Equipment emissions are usually specified as a particular matter (PM) level, normally factored to engine output (for example 0.15 grams per kilowatt hour of engine power). This level includes elemental carbon, organic carbon and other particulate matter such as sulphates. As the atmospheric limits relate only to carbon emission, care must be taken to either factor the emission rate to carbon levels accordingly, or factor the final atmospheric concentration limit so that only the desired carbon levels are used (elemental or total).

What is the actual DP value?

Finally, the diesel engine emission outputs may in some cases be further reduced by the equipment manufacturer or mine utilising catalytic / regenerative converters and particulate filters. This can further lower the emission rate further (by 50% or more) and if present, should be considered in the final DP emission value. Conversely, worn or damaged equipment may produce significantly higher than expected emissions. Where possible, mine sites should measure actual equipment exhaust to obtain actual values, however if this is not possible, then equipment manufacturer advice should be sort, or a conservative approach from EPA data taken.

Application in a Mining Environment

Simulated atmospheric concentrations of particulates are only the first step in what must be a multi pronged approach to controlling exposure levels. Operators of machines may be directly exposed to higher concentrations than predicted due to their proximity to exhaust emissions. Conversely, operators protected by filtered cabins may be exposed to lower concentrations that predicted. Also keep in mind that mine concentrations of DPM which are higher than the allowed standards still may be permissible if other control methods such as reduced exposure time or personnel protective equipment are used to control exposure.

Where control of exposure measures cannot be guaranteed to protect workers, the mine will need to consider implementing engineering strategies such as increased ventilation flow, or improved engine or emission control. Where increase ventilation flows are used, ensure that this has a cost benefit against improve exhaust emission or exposure control. The financial functions in Ventsim Visual provide useful feedback on the additional cost of ventilation – cost which may be better invested in exhaust emission reduction.

13.2 How to perform DPM Simulation in Ventsim

Ventsim Visual uses the diesel equipment placed for heat simulation to also simulate DPM concentrations. Emission rates can be entered either in the Heat Presets, or directly as a manual entry in the EDIT form. Once again, note the atmospheric concentration will be given in the same composition units as the

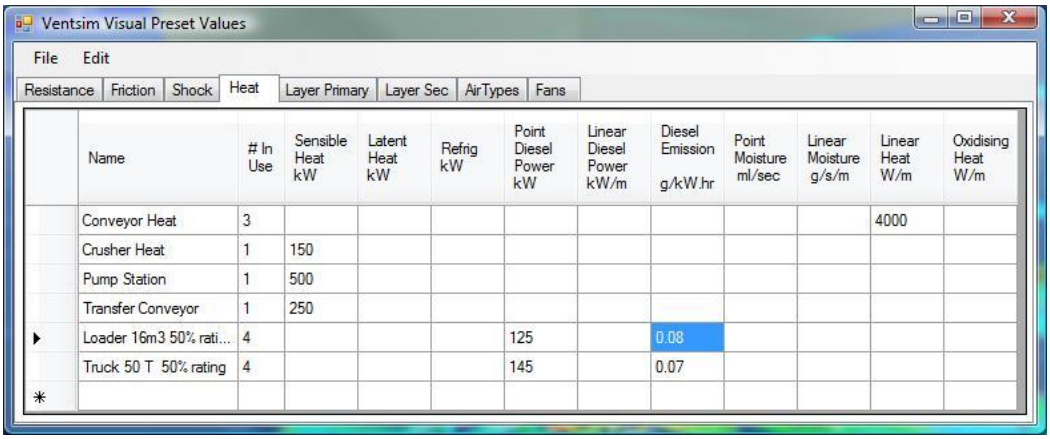
diesel emission assumption (emissions rates are entered as elemental, total carbon, or total particulate matter)

13.2.1 Example

A diesel engine is listed as having a PM (particulate matter) value of 0.16 g/kW-hr. The mine is regulated under an Elemental Carbon limit of 100 ug/m3, and the user has assumed that Elemental Carbon is 50% of Particulate Matter (PM). Therefore the user must either convert the diesel emission rate to elemental carbon (50% = 0.08g/kw-hr) or keep in mind that their actual simulated atmospheric limit is in total DPM instead of Elemental Carbon (200ug/m3).

The Ventsim user decides to convert the PM value to an Elemental Carbon value of 0.08g/kW-hr, and enters this value in the Heat Presets.

Next, the user must decide the **average diesel power output** of the engine during the shift. DO NOT ENTER THE MAXIMUM diesel engine power, as no typical diesel equipment will run at full engine power for the entire shift, and using this value will **over predict** DPM concentrations. The best method is to measure actual fuel consumption for the shift, and use the Heat Assistant in Ventsim to calculate average engine power output. In most cases, trucks and loaders will not exceed 50% of their rated power, and auxiliary equipment and light vehicles will probably be much less.



	Name	# In Use	Sensible Heat kW	Latent Heat kW	Refrig kW	Point Diesel Power kW	Linear Diesel Power kW/m	Diesel Emission g/kW.hr	Point Moisture ml/sec	Linear Moisture g/s/m	Linear Heat W/m	Oxidising Heat W/m
	Conveyor Heat	3									4000	
	Crusher Heat	1	150									
	Pump Station	1	500									
	Transfer Conveyor	1	250									
▶	Loader 16m3 50% rati...	4				125		0.08				
	Truck 50 T 50% rating	4				145		0.07				
*												

Figure 13-1 Diesel Equipment with DPM emissions in Preset Values

The user has five loaders with rated diesel engine power of 250kW each. After observing fuel usage for the shift, the user specifies the machine put out an average of 125kW of diesel power and enters this value in the Heat Presets.

The five (5) loaders are then placed in typical airways around the mine and the DPM SIMULATION function is activated.

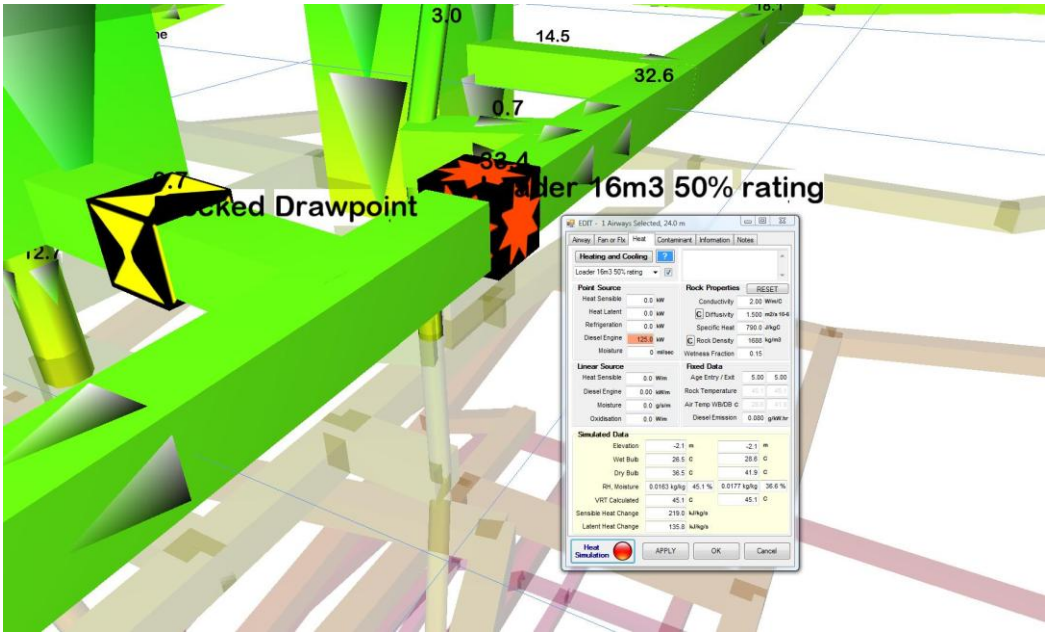


Figure 13-2 Diesel heat and DPM source placed in airway

The DPM levels can be actively viewed around the mine, and the colour ranges adjusted in the Colour Manager to view areas of potential concern. Further changes or increases to air flows will require a re-simulation of the diesel particulates to recalculate new values.

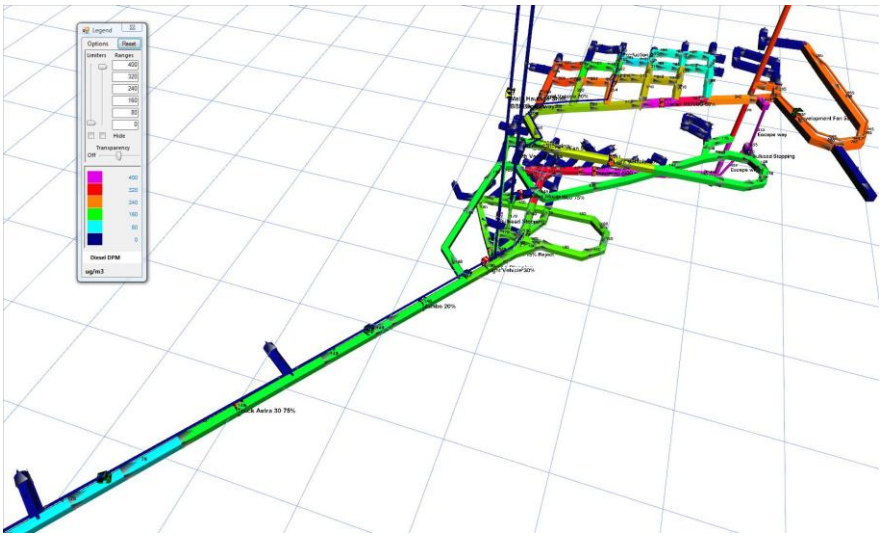


Figure 13-3 Example showing DPM simulation colouring through mine

Chapter

14

Chapter 14 Saving Money

Ventsim Visual™ provides many useful tools to analyse and develop strategies to save money. While the total ventilation cost for most mines is significant, much of the cost remains largely hidden or ignored and treaded as inevitable.

The total cost of ventilation in mines should not only be considered as the direct costs such as power consumed or ventilation fans purchased, but as a whole of mine cost, which includes the development and infrastructure mined, maintenance and upkeep of ventilation system, and productivity gains and losses due to good or adverse ventilation conditions. When ventilation costs are viewed as an integral part of all production activities, the cost of poor ventilation becomes even more substantial.

Ventsim Visual™ includes a number of tools to quickly analyse and help reduce ventilation costs.

14.1 Financial simulation

[Advanced Versions]

Designed to quickly estimate optimum ventilation infrastructure size, by considering mining costs as well as life of mine ventilation operating costs, this function can help optimise airway sizes and save substantial money over the life of a mine. Keep in mind however, when using estimated mine life to optimise an airway size, that in many cases mine life extends far beyond initial estimations as further ore resources are found. Many mines are stuck with an inadequate ventilation system that is stretched far beyond its useful life, because the possibility of mine extensions or expansions was not considered in the early stages of ventilation design.

See the Financial Simulation function for further information

14.2 Cost Data Function

The program contains a number of data types which show ventilation costs per annum for airways. These include fan/fix power costs, friction losses per airway and friction losses per unit length.

Perhaps the most useful way to consider ventilation costs is not to look at the cost of running fans, but rather look at the cost of pushing ventilation through individual airways away from the fans.

Of all the cost data function, perhaps one of the most useful is the friction cost per unit length. This describes the friction pressure loss along an airway length, and is directly proportional to the ventilation cost per unit length of development.

For example, if a particular airway reports a ventilation operating cost due to friction loss of $800/yr per metre, then over a mine life of 10 years, the total cost of pushing ventilation through the heading is $8000 per metre. It is not hard to see that increasing the mined airway size slightly for (say) an additional mining cost of $500 per metre will quickly pay dividend in reduced ventilation costs.

By using the Ventsim Visual™ Colour Manager, and colouring data to the ventilation cost per annum per unit length, high cost airways will be highlighted, and can be quickly identified and analysed for potential different sizes.

14.2.1 Example

In the 'Blue-Sky' example presented below, the data colour display is set to Head Cost/L (friction pressure cost per metre). The colour sliders are adjusted to show airways costing greater than $2 per metre per year. Airways below this are made transparent to clarify the display.

The data clearly shows in particular two air shafts with extremely high costs per metre, one in particular at over $600 per metre per year, as well as a horizontal connecting airway costing nearly $300 per metre. If the mine life was substantial, it would not be hard to justify enlarging or installing a second shaft system to reduce overall ventilation costs.

In this case, increasing shaft size from 3.0m to 3.5m reduced per metre annual ventilation costs from $600 per metre to $250 per metre. Over 10 years, this would result in a saving of $400,000 for this relatively short airway.

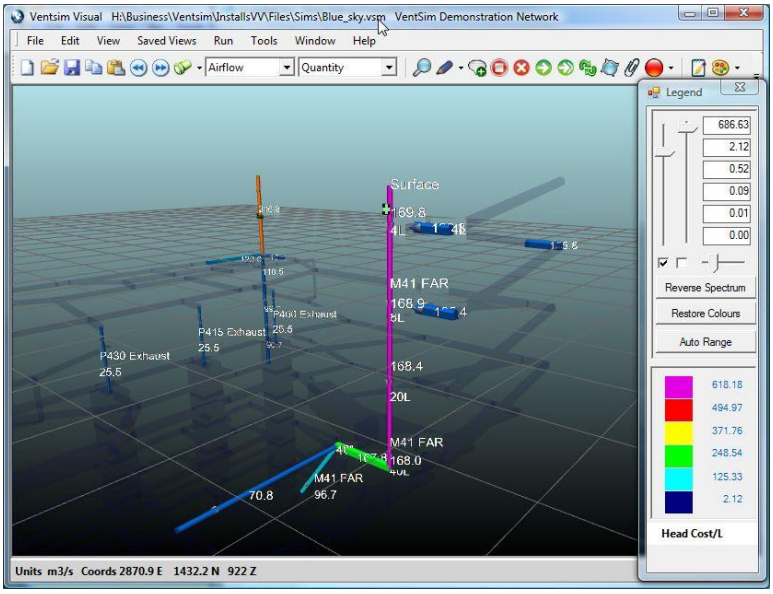


Figure 14-1 High Cost Airways coloured to show clearly

14.3 Ventilation on Demand.

An increasingly popular method of reducing ventilation costs is applying ventilation only when and where it is needed. While simple in principle, this fundamental approach provides significant challenges when applied to complex networks. Changes or reductions in ventilation flows can significantly impact other areas of the mine, resulting in recirculation and heat and gas build up.

Using Ventsim Visual, different scenarios can be easily examined by simulating the potential changes, such as reducing or turning off fan flows or reducing refrigeration.

The **network summary** will predict savings made in ventilation costs and power for the change.

The **recirculation checker** in Visual Advanced will quickly check for any recirculation resulting from the change.

The **contamination and diesel particulate** tools (in the Advanced version) will estimate any change to exhaust and potential fume.

The **thermodynamic simulator** will identify any unacceptable changes to temperature

Doors, fans and stopping can be quickly placed to control network airflow to acceptable levels and provide useful information as to what automatic controls may be required to achieve the ventilation changes.

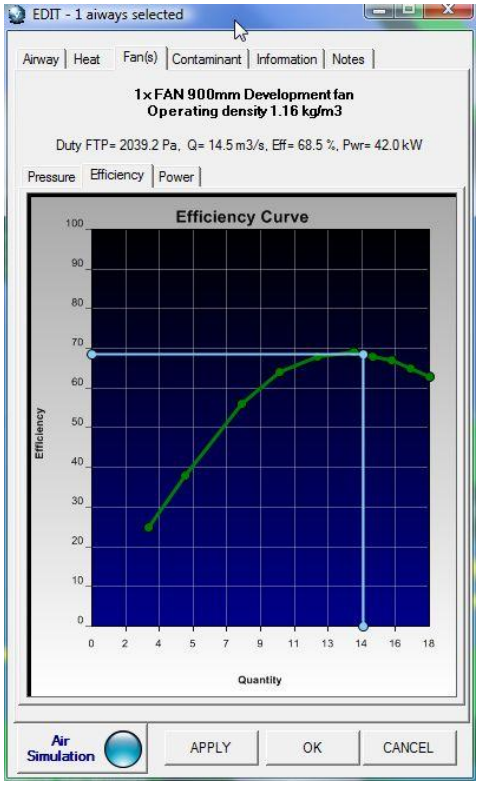
14.4 Fan Optimisation

Correctly sized fans can significantly reduce operating costs.

Ensure airflows are not significantly overdesigned, and fan curves and duty points are closely matched to run efficiently. Many fan curves rapidly lose efficiency away from the central duty points, resulting in poor performance and excessive power consumption.

The fan efficiency and power consumption can be examined under the **Edit Box** fan menu. Ideally, the fan efficiency should have the operating duty point close to the maximum fan efficiency.

A further way to boost fan flow and efficiency is to ensure an evasé is fitted to surface exhaust fans. Fan evasés reduce surface velocity pressure losses, increasing available fan static pressure to overcome mine resistance. The overall effect is improved airflow at a similar cost.



Finally, overall network efficiency is largely influenced by the configuration of fans throughout a network. The use of 'in-series' booster fans underground for a single primary ventilation circuit should generally be avoided if possible, as fan efficiencies are compounded as the same airflow travels through each fan (booster fans may however be useful in directing airflow into parts of a mine which would otherwise require inefficient regulators on the primary vent flow to do so). The result compared to a single pass fan system is higher power for

similar airflow. The overall network efficiency is available from the network summary function.

Chapter

15

Chapter 15 Network Examples

Several network examples are included with the Ventsim program. The first example below describes the method used in creating the network file EXAMPLE1.VSM

15.1 Example 1

An underground mine is to be designed from near the base of an open pit that is 100m deep. A decline will extend down some 140m below the pit floor, travelling adjacent to a sub vertical orebody. Three drilling / production sub levels will branch off the main decline every 40 vertical metres, starting at 60m below the pit floor. Main production will be from the bottom two levels. A ventilation shaft some 400m away (outside the pit boundary) extends from the mine base to the surface, connecting all sub levels. An exhaust fan on the shaft will need to pull 150m3/s to supply the mines production needs. Fresh air is supplied to the mine via the main decline.

6. Conceptually design a mine ventilation network incorporating the three simple sub levels. Ensure air is supplied equally to each level.

7. Due to power restrictions, main exhaust fan power must not exceed 200kW. What diameter shaft should be mined?

8. Emergency plans require stench gas to be delivered from the decline portal to all parts of the mine. What is the maximum time for the stench gas to be delivered to all areas of the mine?

15.1.1 Suggested Steps

Construct a Level elevation database with a surface level from 0 to -100 and subsequent RL levels -160, -200, and -240.

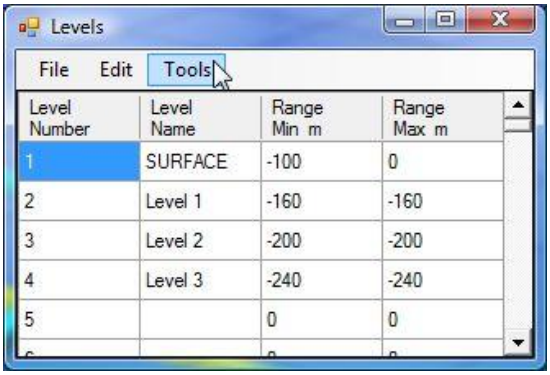


Figure 15-1 Establish a level elevation database

9. Select the toolbar ADD function , and set the view to Plan.

10. Establish an initial working elevation by using the Set Edit Centre function under the View menu.

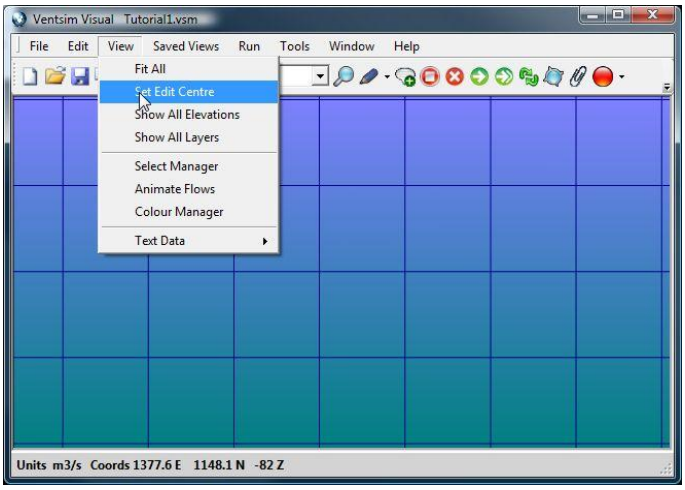


Figure 15-2 Set the starting edit location

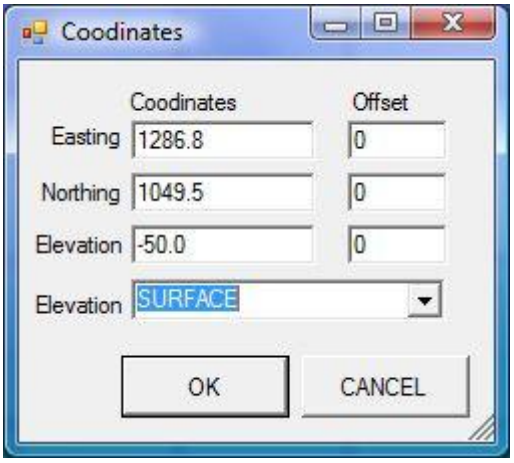


Figure 15-3 Enter the starting elevation of the drawing (edit) plane

11. Draw a decline loop, using the grid squares as guides for scale. Do not join the decline loop back upon itself, instead pull up just short. The decline loop will initially be flat on the same elevation. Don't worry – we will change that soon.

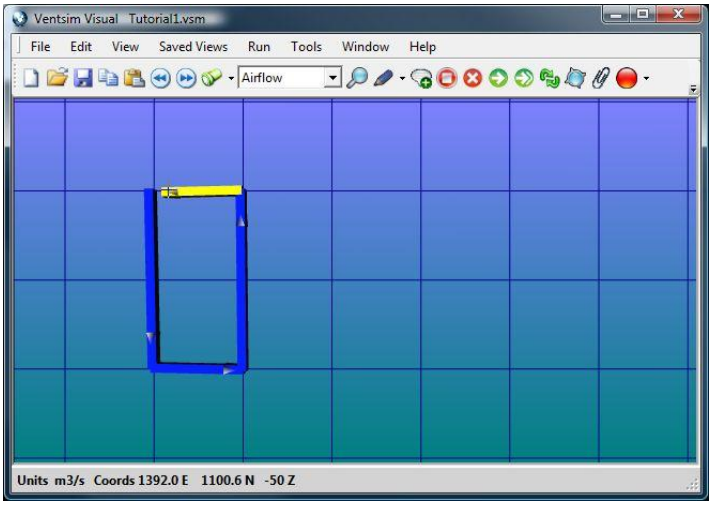

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Airflow
Units m3/s Coords 1392.0 E 1100.6 N -50 Z

Figure 15-4 Construct and initial 'flat' decline loop

12. We need to adjust each leg of the decline, so it ramps down. Select the toolbar **move** function, and click on each decline junction node, adjusting the elevation of each to move progressively down. Rotate the display slightly so progress can be viewed.

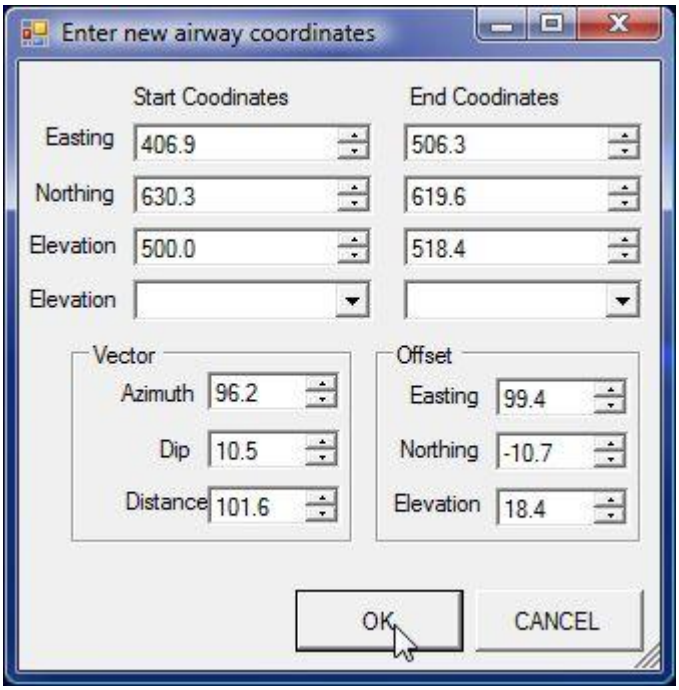


Figure 15-5 Example Move the decline loop nodes by offsetting the elevation

13. Now we have a complete decline loop, we can simply copy it to progress down further. Use the toolbar **copy** command and fence select the decline loop. Then grab the upper end with the mouse cursor, and drag it down to join onto the lower leg. A new decline loop has been made. Repeat this

action several more times to construct the decline to the underground levels.

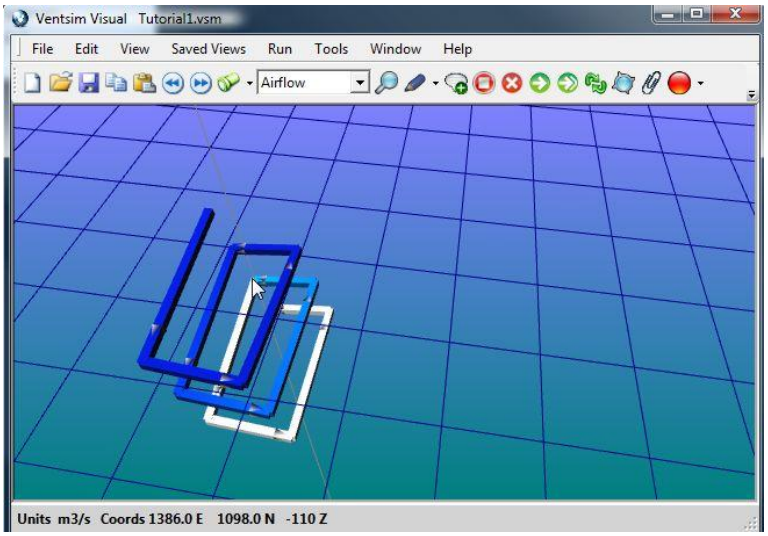

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Airflow
Units m3/s Coords 1386.0 E 1098.0 N -110 Z

Figure 15-6 Copy the selected decline loop to lower levels and repeat

14. Once the decline is established to the proposed base level of the mine, use the Set Edit Centre under the View menu to set the grid to the first sub level. Draw a sublevel across to a point at the right of the screen. To draw a shaft, start a new horizontal airway, and then hold the shift key to draw the airway vertically. Use the edit plane (semi-opaque sheet) to judge where to finish the shaft at the surface. Alternatively, you could set the draw function to manually allow coordinate entry to establish the shaft.

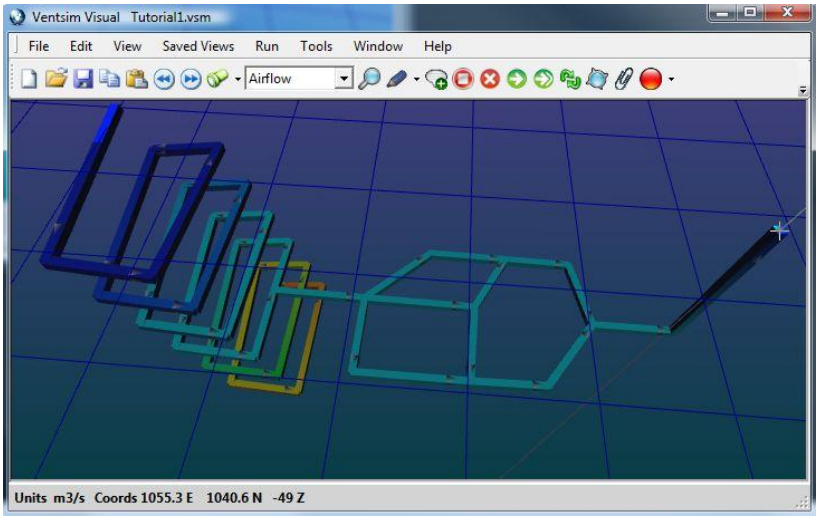

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Airflow
Units m3/s Coords 1055.3 E 1040.6 N -49 Z

Figure 15-7 Construct a shaft to the surface

15. Repeat the above step to produce two more sub-levels. Extend the shaft at the right to join to the two lower sub-levels.

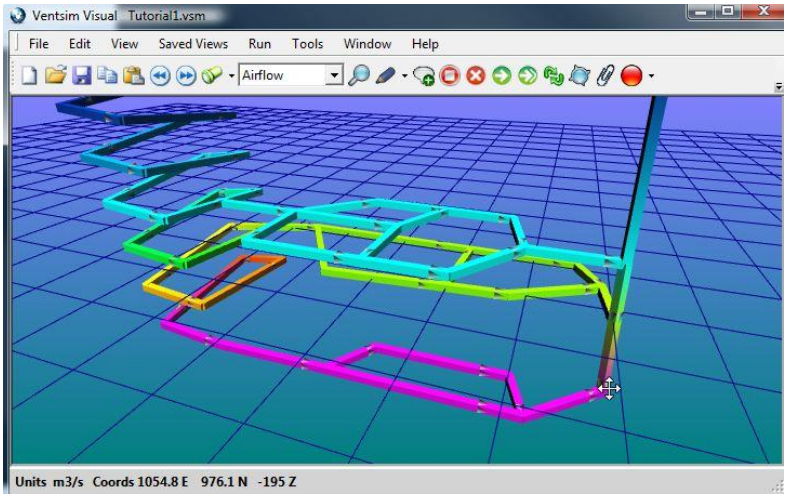

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Airflow
Units m3/s Coords 1054.8 E 976.1 N -195 Z

Figure 15-8 Draw multiple levels for the mine

16. Edit the shaft airways and set them to a required size. Label the airway, and set the airflow as a **fixed airflow** to the desired amount of 150m3/s. Ensure the airway has the 'Surface Connection' checked. Click on the top decline airway, and also ensure the 'Surface Connection' is checked. Click on **Air Simulation** to ensure everything works correctly.

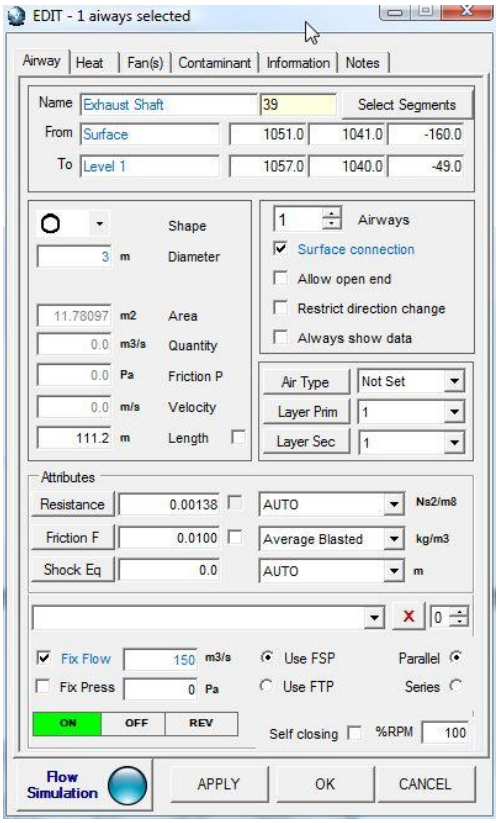


Figure 15-9 Edit the airway to set the airway size

17. Click on the sublevel entries to the exhaust shaft. Set the 1st and 2nd sublevel airflows to 50m3/s. The lower sublevel will automatically simulate to 50m3/s to balance the 150m3/s total airflow into the shaft. Clicking on the Edit Box info will show the required resistance to produce this airflow.

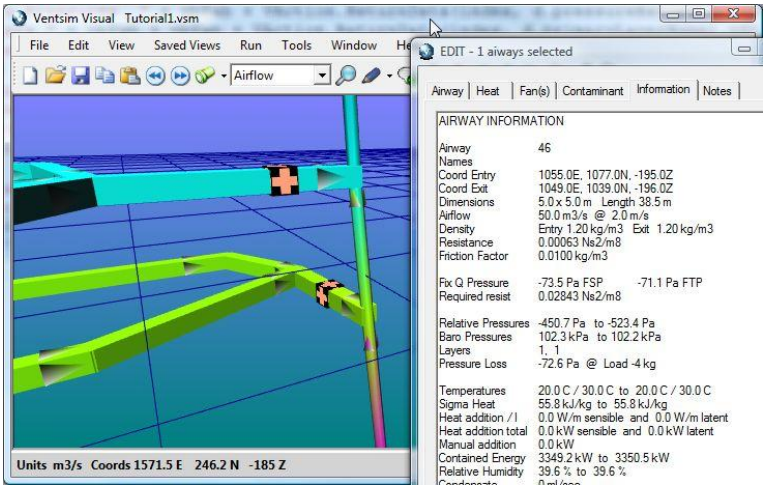

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window
Airflow
EDIT - 1 aiways selected
Airway | Heat | Fan(s) | Contaminant | Information | Notes
AIRWAY INFORMATION
Airway 46
Names
Coord Entry 1055.0E, 1077.0N, -195.0Z
Coord Exit 1049.0E, 1039.0N, -196.0Z
Dimensions 5.0 x 5.0 m Length 38.5 m
Airflow 50.0 m3/s @ 2.0 m/s
Density Entry 1.20 kg/m3 Exit 1.20 kg/m3
Resistance 0.00063 Ns2/m8
Friction Factor 0.0100 kg/m3
Fix Q Pressure -73.5 Pa FSP -71.1 Pa FTP
Required resist 0.02843 Ns2/m8
Relative Pressures -450.7 Pa to -523.4 Pa
Baro Pressures 102.3 kPa to 102.2 kPa
Layers 1, 1
Pressure Loss -72.6 Pa @ Load -4 kg
Temperatures 20.0 C / 30.0 C to 20.0 C / 30.0 C
Sigma Heat 55.8 kJ/kg to 55.8 kJ/kg
Heat addition / l 0.0 W/m sensible and 0.0 W/m latent
Heat addition total 0.0 kW sensible and 0.0 kW latent
Manual addition 0.0 kW
Contained Energy 3349.2 kW to 3350.5 kW
Relative Humidity 39.6 % to 39.6 %
Units m3/s Coords 1571.5 E 246.2 N -185 Z

Figure 15-10 Add a fixed airflow to the airway

18. Adjust the shaft diameter until the required power constraints are met. Ensure you simulate the network between each adjustment. In this case, a shaft size of 3.6m was found to produce the desired result. The required duty point is 965Pa Total Fan pressure, 150m3/s with a fan motor size of 181kW and an electrical power consumption of 190kW.

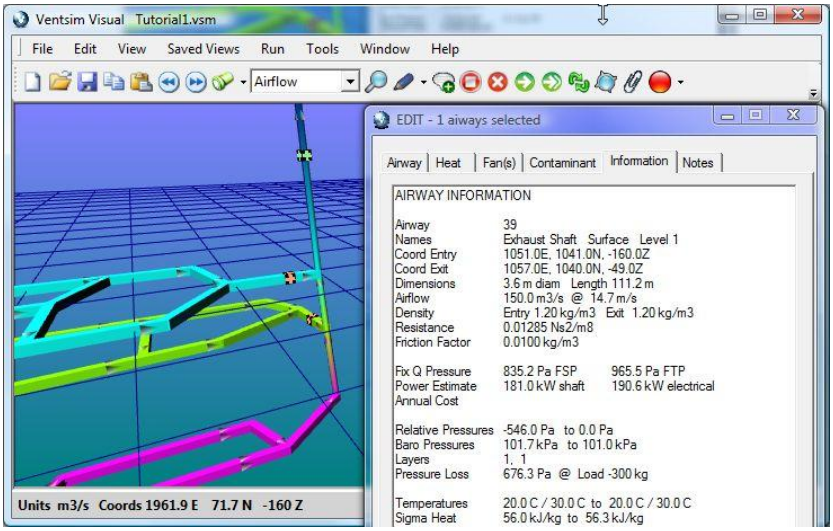

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Airflow
EDIT - 1 aiways selected
Airway | Heat | Fan(s) | Contaminant | Information | Notes
AIRWAY INFORMATION
Airway 39
Names Exhaust Shaft Surface Level 1
Coord Entry 1051.0E, 1041.0N, -160.0Z
Coord Exit 1057.0E, 1040.0N, -49.0Z
Dimensions 3.6 m diam Length 111.2 m
Airflow 150.0 m3/s @ 14.7 m/s
Density Entry 1.20 kg/m3 Exit 1.20 kg/m3
Resistance 0.01285 Ns2/m8
Friction Factor 0.0100 kg/m3
Fix Q Pressure 835.2 Pa FSP 965.5 Pa FTP
Power Estimate 181.0 kW shaft 190.6 kW electrical
Annual Cost
Relative Pressures -546.0 Pa to 0.0 Pa
Baro Pressures 101.7 kPa to 101.0 kPa
Layers 1, 1
Pressure Loss 676.3 Pa @ Load -300 kg
Temperatures 20.0 C / 30.0 C to 20.0 C / 30.0 C
Sigma Heat 56.0 kJ/kg to 56.3 kJ/kg
Units m3/s Coords 1961.9 E 71.7 N -160 Z

Figure 15-11 Use the Edit – Info to view airway flow, pressure and power

19. To perform a stench gas simulation, place a contaminant in the upper decline with the Edit Box. Set the contaminant to a strength of 100, and run the contaminant simulation. The colour display will initially show a strength of 100 is spread all through the mine, which is to be expected as the decline is the only source of fresh air. Change the Colour Manager to

show ‘Spread Time’. The lower corner will show spread times of up to 700 seconds or around 12 minutes.

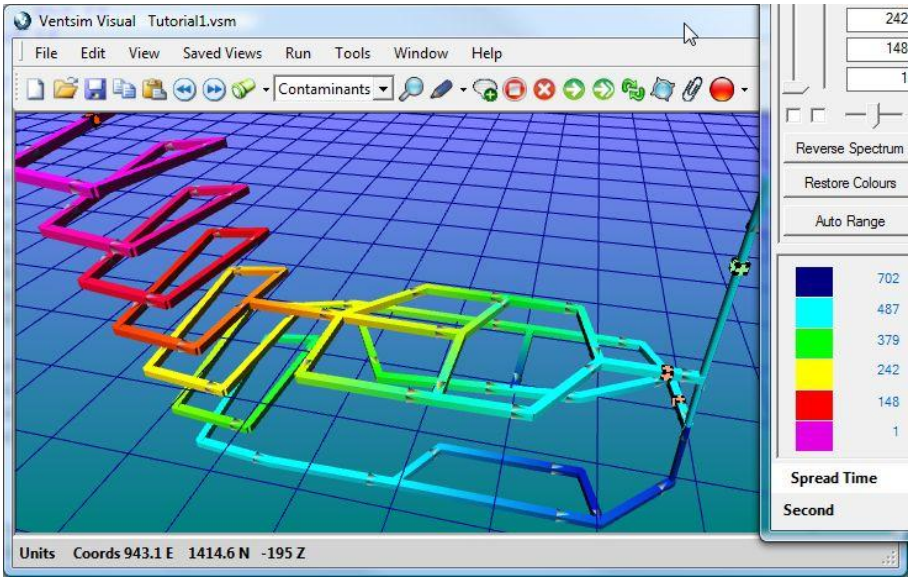


Figure 15-12 Colouring showing contamination spread time in seconds

If you got this far, congratulations!

The complete example is available from the Ventsim Visual™ installation folder under Examples.

15.2 Example 2

A skeleton network has been created in a mine planning package by tracing over the existing and planned development and exporting the file as a DXF format file. Import this file into Ventsim and adjust it to create a workable network. Note that the decline is 5.5m x 5.5m, the sub level drives are 4.0m x 5.0m and the ventilation shafts are 2.4m diameter.

20. Create an RL database that separates the mine into each sub-level. Create a RL that also displays the entire mine.

21. Create three PRIMARY Layers, and set the DECLINE, SUB-LEVEL and SHAFT airways to these Layers.

22. Divide the mine into fresh & exhaust air with the DECLINE carrying fresh air, and the SHAFT and the upper sub level carrying exhaust.

23. Create some saved views showing the;

    - whole mine with exhaust and fresh air showing.
    - decline by itself.
    - two upper sub-levels and corresponding shafts.

15.2.1 Suggested Steps

24. Initially set the default airway sizes (in the Settings Airway menu) to 4.0 x 5.0m. This will set all imported DXF airways to these defaults sizes, and therefore the majority of airways will not need to be adjusted after importing.

25. IMPORT the DXF file into Ventsim.

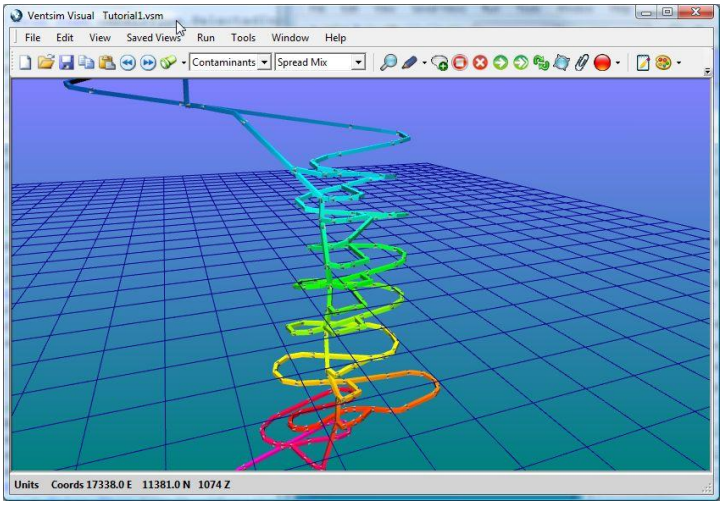

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Contaminants
Spread Mix
Units Coords 17338.0 E 11381.0 N 1074 Z

Figure 15-13 Initial imported DXF strings in Ventsim Visual

26. Create an RL database with the RL MIN & MAX covering each sub-level range.

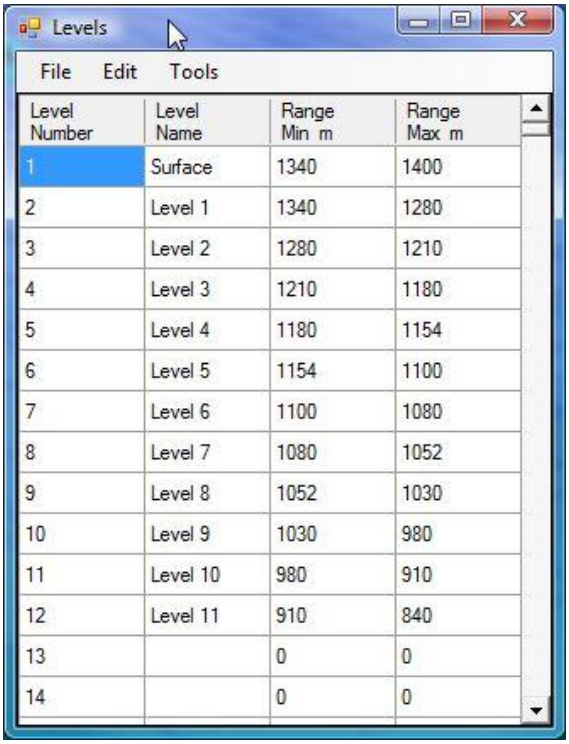


Figure 15-14 The Level Elevation database

27. Create the new Primary layer names from any airway in the Edit Box.

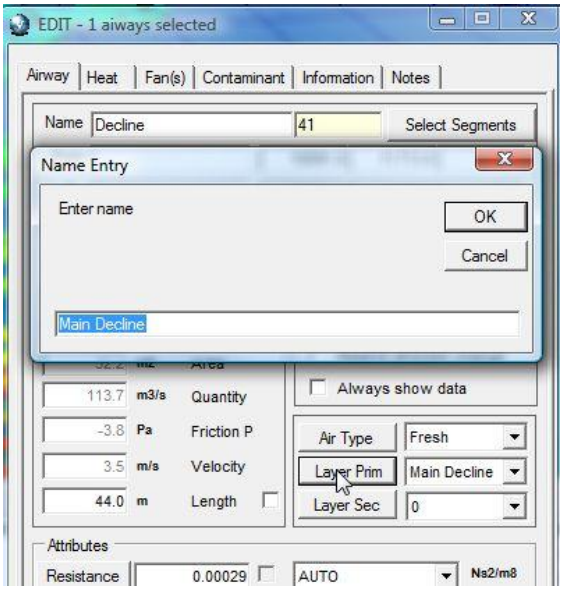


Figure 15-15 Set airway names

1. Use the group edit function to select the decline airways
2. Use the **select toolbar button** to select all decline airways

3. Use the edit toolbar button to edit all selected airways.
4. Change the primary layer name to Decline
5. Change the air type to Fresh
6. Change the airway dimensions to 5.5m x 5.5m
7. Apply the changes to the selected airways

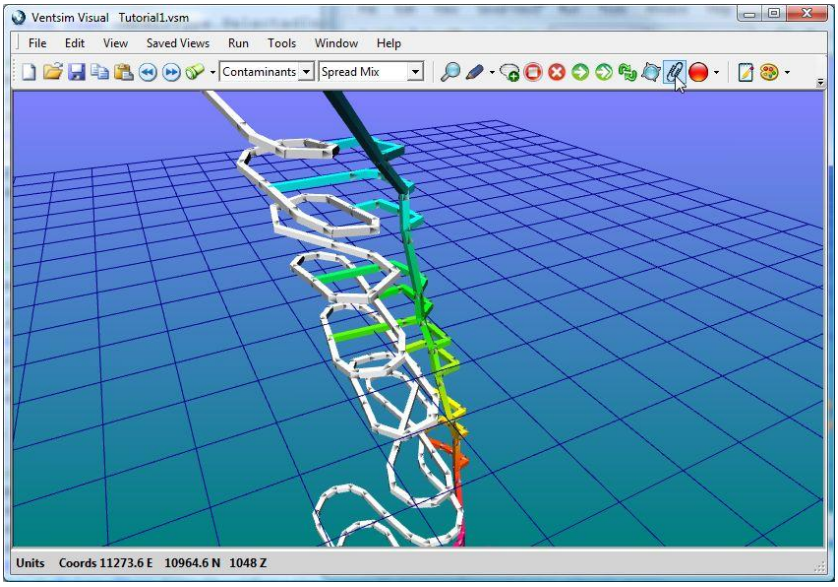

Ventsim Visual Tutorial1.vsm
File Edit View Saved Views Run Tools Window Help
Contaminants
Spread Mix
Units Coords 11273.6 E 10964.6 N 1048 Z

Figure 15-16 Initial selection of all decline airways

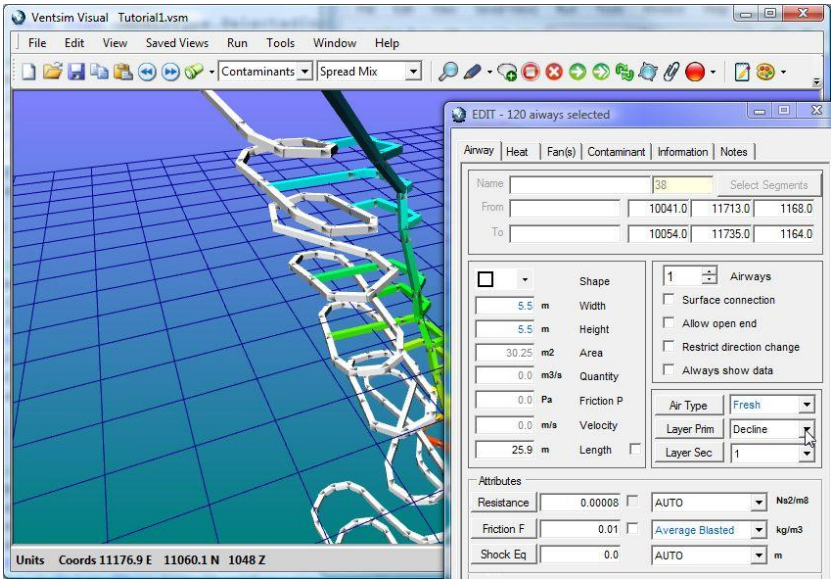


Figure 15-17 Select and edit the decline airways

28. Repeat the above actions to set the other airways parameters for shafts and sub-levels.

29. Finally, add fans, ventilation controls and stoppings to direct airflow through the network

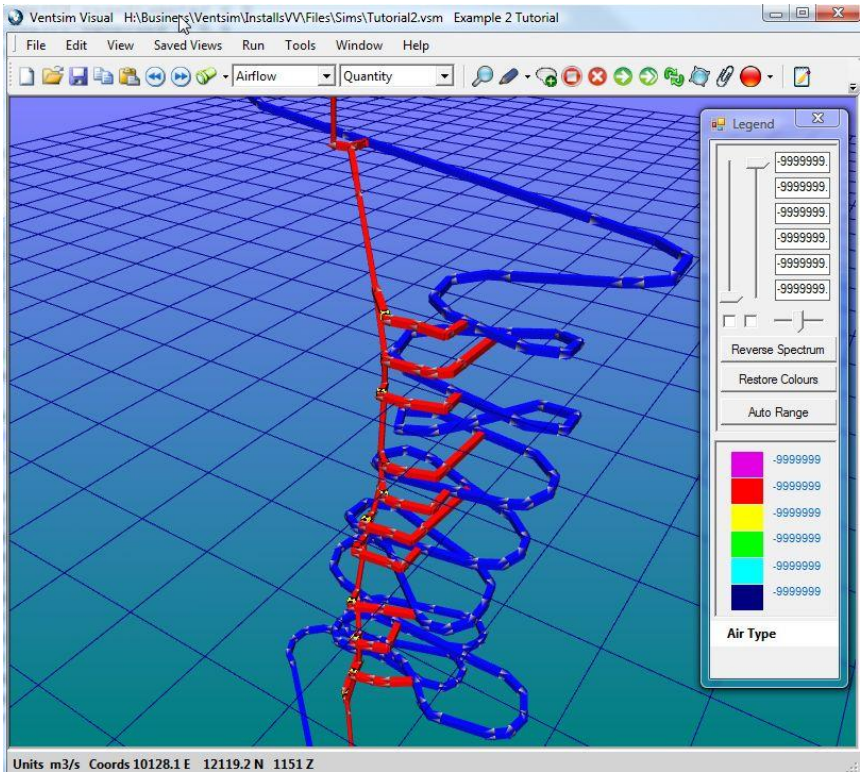
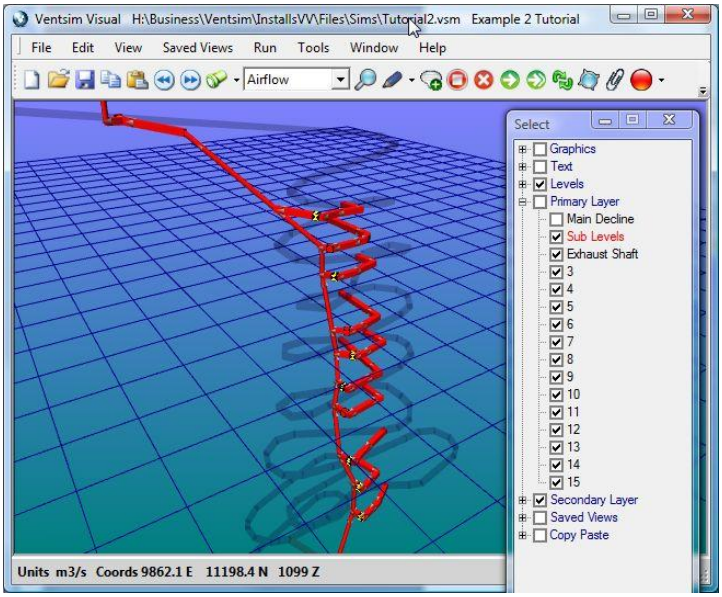


Figure 15-18 Fresh and Exhaust Air Type colouring

30. To limit the view to the decline or shafts only using the layer control in the display selection to control which layers are displayed.



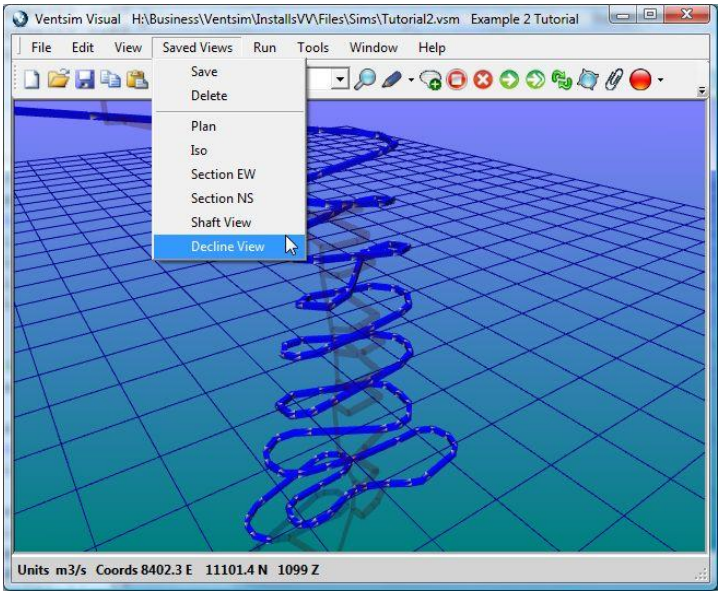


Figure 15-19 The final DXF import result showing the decline and the exhaust shafts displayed independently with layers.

Chapter 16 APPENDIX A – Glossary of Terms

16.1 A glossary of commonly used terms

16.1.1 Airway An section of underground tunnel defined by two end points.

16.1.2 Branch An airway

16.1.3 TXT TAB Separated Value - a text file format used by Ventsim when saving files. This format can also be read into Spreadsheets, Word Processors and databases.

16.1.4 DXF Drawing Exchange Format - An AutoCAD graphics file format that can be imported and exported by most CAD and Mining Software packages. Ventsim can also import or export data in this format.

16.1.5 Endpoint / Start point The start or end of an airway, defined by an x, y and z coordinate, which gives its position in space in three dimensions.

16.1.6 Friction cost same as friction power, with the kilowatt value converted to a dollar cost per annum, based on the default power cost.

16.1.7 Friction factor or k factor Atkinson's friction factor, describing the roughness or unevenness of a wall. It directly affects the resistance of an airway. Friction factors are measured to a specific air density, normally normalised to 1.2.kg/m3

16.1.8 Friction loss A component of pressure drop along an airway caused by the airway resistance.

16.1.9 Friction power Derived from the friction loss, this estimates (in kilowatts), the amount of energy lost due to the resistance of an airway on the airflow.

16.1.10 Hardy- Cross Method The simulation method used by Ventsim Visual™ to perform the calculation of airflows in a network. It uses an iterative estimation method that adjusts the airflows through a network until the estimation errors lie within acceptable limits. Ventsim Visual™ Advanced uses a modified method which takes into account density changes and mass flow balances.

16.1.11 Junction A point defining where two or more airway ends share the same position. Airflow at this point can split or join, depending on airflow direction.

16.1.12 Load (Pressure) Estimation of how much load or weight an airway pressure loss would develop across a resistance. It is often used for determining load on a vent door or bulkhead and is calculated by the pressure loss times by the drive or resistance area..

16.1.13 Node A point defining the end or junction of an airway(s)

16.1.14 Pan The action of sliding the network graphics to a new screen position by using the right mouse button.

16.1.15 Pressure loss The loss of air pressure along a length of airway due to friction loss, fans, fixed pressures or fixed quantities etc.

16.1.16 Resistance A value describing the difficulty air will have moving down an airway. It is derived from a combination of airway size, friction factor, length, shock losses and air density.

16.1.17 Shock loss

A factor that estimates the effect a change in drive direction or size has on airflow. Any such change will increase turbulence in an airflow, and hence develop energy losses that can be equated to an increase in airway resistance. Ventsim Visual™ uses shock loss as an extra length added on to the original drive length (i.e. the higher the shock loss, the greater the equivalent length), which in turn increases the overall airway resistance.

16.1.18 Thermal Diffusivity

Thermal diffusivity is the ratio of thermal conductivity to volumetric heat capacity. Substances with high thermal diffusivity rapidly adjust their temperature to that of their surroundings, because they conduct heat quickly in comparison to their volumetric heat capacity or 'thermal bulk'

16.1.19 Thermal Conductivity

Thermal conductivity, k, is the property of a material that indicates its ability to conduct heat. It appears primarily in Fourier's Law for heat conduction.

16.1.20 Wetness Fraction

The ratio of area of wet airway surface to dry airway surface. A fully wet surface is defined as '1.0' while a fully dry surface is defined as '0.0'

16.1.21 Relative Humidity

Relative humidity describes the amount of water vapour that exists in a gaseous mixture of air and water. It is defined as the ratio of the partial pressure of water vapour in the mixture to the saturated vapour pressure of water at a prescribed temperature. Relative humidity is normally expressed as a percentage

16.1.22 Density

The density of a material is defined as its mass per unit volume. The density of air influence many psychrometric properties. Te density of rock influences heat transfer and thermal capacity behaviour.

Chapter 17 Appendix B – Summary Data Types

17.1 Summary of the major data types

Available from the data selection menus in the menu bar. Note that additional data and data subsets are available in the spreadsheet view.

17.1.1 Air types

Airtype The type of category of air in the network. Originally designed for specifying fresh, exhaust and undetermined air within a network, Ventsim Visual allows custom catagories for air types, set from within the Edit menu. When specified in the Colour Manager, airtype will show different colours for different air types.

17.1.2 Airflow

Quantity The volume flow rate of air through an airway

Velocity The average speed of airflow through an airway across the cross sectional area

Density The average air density along an airway. For vertical shafts, this is the air density mid way along the shaft.

Mass Flow The mass flow of air through an airway. This is a function of volume flow and air density.

17.1.3 Pressure

Pressure Boost The increase in pressure provide to a network system by an external source, such as a fan or fixed flow.

Pressure BoostStatic The fan static pressure equivalent of the pressure boost.

Pressure Regulator Load The pressure or force against an airway resistance converted to an equivalent 'weight'

Pressure TotalLoss The total pressure loss along and airway between entry and exit. Pressure loss may consist of airway friction pressure losses, due to wall friction factors and additional resistances placed in the airway

Pressure Relative The relative pressure differential between underground airway and the surface, standardised to the surface elevation. A relative pressure differential of zero, would result in no flow from a connecting airway to the surface. A negative relative pressure would see air flow from the surface to the underground airway if a path was present. A positve relative pressure would see air flow from underground to the surface if a path was present.

Pressure Absolute The pressure reported in atmospheric units of an underground airway, corrected to surface elevation. The correction removes the effect of elevation on pressure, and permits a relative assessment between airways at different elevations.

Pressure Barometric The true pressure reported in total atmospheric units including the elevation effects on total pressure. Barometric pressure increases with depth, where no other pressure influences are present.

Pressure FrictionLoss The loss of pressure along an airway due to wall friction. This ignores any other resistances in the airway such as doors or stoppings.

Natural Ventilation Compares density differences of a column of mine air with an equivalent column of atmospheric air and applies a pressure differential. Every airway with a different entry and exit elevation has potential to have some natural ventilation. Ventsim Visual uses a +(ve) number convention to describe upwards (buoyant) natural ventilation and –(ve) to show downward (sinking) natural ventilation.

Note that by default, atmospheric density is adjusted for temperature gradient (lapse) rate, in much the same way as auto compression can drive changes in underground temperature at different elevations. Inlet airways at different elevations will have different temperatures which are derived from the standard elevation and default surface temperature. This function can be turned off in the settings if desired.

17.1.4 Airway Attributes

Resistance Total airway resistance along an airway. The resistance is standardised to the surface density, and includes any additional resistance added by the user such as doors and stoppings.

Resistance Wall Resistance due to airway wall friction along an airway. It does not include any additional resistances added.

Shock The shock value reported as either a shock factor (X) or an equivalent airway length. Both factor types add additional resistance to an airway, and increase pressure loss due to air turbulence caused by a bend, change of size or other obstruction. The shock length type can be set in the setting menu.

Friction Factor kfactor Atkinsons friction factor describing the uneveness of an airway wall, resulting in near surface turnulence and increase airway resistance. Friction factors are standardised to the surface density.

Dimensions The size of an airway width and height as the centre section.

Perimeter The perimeter of an airway, calculated from the centre height and width, taking into account the airway shape profile. The perimeter can also be set directly from the edit menu.

Area The area of an airway, calculated from the centre height and width, taking into account the airway shape profile. The area can also be set directly from the edit menu.

Length The true length of an airway, used to calculate airway resistance and heat transfer. It does not include additional shock lengths if specified.

Coordinates Report the coordinates of an airway in eastings, northing and elevation.

17.1.5 Energy, Power Cost

Power Loss The friction loss along an airway converted to an equivalent theoretical work load. This value does not include power efficiencies which would result if the pressure loss was to be overcome electrically.

Power Loss/L The friction loss along an airway converted to an equivalent theoritical work load per unit length. Because the loss is standardised to a unit length, this value is independent of the actual length of the airway.

Power Input The electrical input power into a network to generate pressure and airflow. The power input includes efficiency losses due to fan blade efficiency but does not include motor efficiency losses.

Head Cost The theoretical cost of the power loss due to friction converted to an annual electrical cost, based on the power cost set in the Settings.

Head Cost/L The theoretical cost of the power loss per unit length due to friction converted to an annual electrical cost, based on the power cost set in the Settings. Because the loss is standardised to a unit length, this value is independent of the actual length of the airway.

Fan/Fix Cost The electrical input power by a fan or theorectical fix flow into a network to generate pressure and airflow. The electical input includes both fan or fix efficiency factors and an electrical motor efficiency factors specified in the Settings.

17.1.6 Thermo - dynamics

Wet bulb Psycrometric properties of air decribing the temperature a volume of air would have if cooled adiabatically to saturation at constant pressure by evaporation of water into it.

Dry bulb Psycrometric property of air describing the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture.

Dew point The dew point is the temperature to which a given parcel of air must be cooled, at constant barometric pressure, for water vapor to condense into water.

Cooling Power cooling power of mine air determines the capacity of the ambient atmosphere to dissipate the metabolic heat generated by humans. The cooling power is measured in W/m2 (amount of heat removes from the human body per second per unit surface area) to keep skin temperature (ACPM method) or body core temperature (TWL method) below safe limits. It is dependent mainly on the wet bulb temperature and the air velocity.

TWL Method. Developed in Australia and based on body core temperature limits, the Thermal Work Limit method has been developed from a physiological basis and ratified by the Australian Institute of Occupational Hygienists (AIOH). It has been adopted by most Australian mines, and uses standard clothing and sweat factors. The method ideally requires globe temperatures for accurate resutls. As

these are not available from a simulation, the TWL may be underestimated for workers around radient heat sources such as machinery or hot rock.

ACPM Method. Developed in the USA, the Ar Cooling Power (M scale) method is based around limiting skin temperature factors as an indicator to body core temperature. The method is in use in most North American mines. Results are highly dependent on clothing and work output factors. Ventsim Visual initially defaults to standard light clothing. Again the method ideally requires globe temperatures for accurate resutls. As these are not available from a simulation, the ACPM may be underestimated for workers around radient heat sources such as machinery or hot rock.

Sigma Heat The sum of sensible heat and latent heat in a substance above a base temperature, typically zero (0) degree Celcius or 32 degrees Fahrenheit. Sigma Heat is independent of dry bulb temperature, relying only on wet bulb temperature and pressure to derive it value.

Enthalpy Similar to Sigma heat, it is the sum of the total heat content of a unit weight of air (including the water vapour) at typically zero (0) degree Celcius or 32 degrees Fahrenheit. Unlike Sigma Heat, it does not however take into account the adiabatic saturation process, and is therefore not as useful pscrometrically.

Energy Flow The sum product of air 'mass' flow and Sigma Heat along an airway. The value is useful to determine the amount of heat an airflow has gathered or lost along an airway.

Relative Humidity Relative humidity describes the amount of water vapour that exists in a gaseous mixture of air and water. It is defined as the ratio of the partial pressure of water vapour in the mixture to the saturated vapour pressure of water at a prescribed temperature. Relative humidity is normally expressed as a percentage

Moisture Content The unit mass of moisture per unit mass of dry air

Condensate The volume flow rate of moisture condensed from an airflow (normally due to refrigeration or pressure drop up a shaft)

Heat Added/L Sensible plus Latent heat from all airway heat sources per unit length

Sensible Heat/L Sensible heat from all airway heat sources per unit length

Latent Heat/L Latent heat from all airway heat sources per unit length

Sensible Heat Sensible heat from all airway heat sources

Latent Heat Latent heat from all airway heat sources

External Heat Heat added or removed by the user, excluding strata heat input.

17.1.7 Identifiers

Airway Number The internal array number of an airway, reference by Ventsim Visual. Ventsim Visual™ will report this number during error description. The airway number may change as airways are added or removed from the network.

Unique ID Number A unique number assigned to every airway, that does not change when airways are added or removed. As a result, the numbers may not be sequential and may have large gaps in the sequence.

Primary Layer The layer nane and number of an airway primary layer

Secondary Layer The layer nane and number of an airway secondary layer

17.1.8 Contaminants

Spread Mix Contaminant simulated concentrations through a network. The value is unit independent and is normally relative in concentration to the original set values.

Spread Time The time in seconds that contaminant takes to appear in airways downstream from the source. The time is calculate by an average cross-sectional speed along all airways. It does not take into account the changing velocity profile, or incomplete mixing at junctions. As a result, it is likely in most cases, that a smaller portion of the contaminant will arrive at an airway location ahead of the predicted time.

Source Mix The portion of a contamination that has tranvelled along upstream airways to the location of the set contaminant. The value is a ratio of the airflow that contributes to the total volume of air flowing through the contaminant source airway.

Diesel Particulate Matter Weight per unit volume of diesel particulate matter in a volume of air.

17.1.9 Rock Properties

Conductivity Thermal conductivity of rock in the airway.

Density Density of rock in the airway.

Specifc Heat The specific heat of rock in the airway

Wetness Fraction The fraction of wet to dry surface of the rock in the airway. A fraction of one (1) represent fully wet, while zero is dry.

Age The age of the rock since exposed by mining in either decimal years (eg 2005.5 = end June 2005) or by a fixed relative age (eg 4.5 = 4.5 years or 4 years and 6 months)

Thermal Diffusivity The thermal diffusivity of rock within an airway.

Chapter 18 Appendix C - Icon Spotters Guide

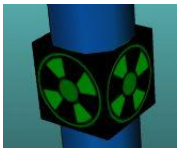
18.1 Airway Icons

A number of **icons are used in Ventsim Visual to represent various airway attributes**. The icons are displayed on top of the airway solid or wireframe, and indicate the presence of a specific item. Multiple attributes represented by icons are shown side by side.

Icons can be turned off or on from the Display Manager or from the right mouse button context menu.

Icons can be MOVED along airways by selecting the MOVE function from the toolbar and dragging the icons along the airway with the left mouse button.

18.1.1 Fans



Fan icons are used to **represent the presence of a fan**. Fans can be shown in four different colours.
Green – normal operating fan

Blue – fan turned off and not operating

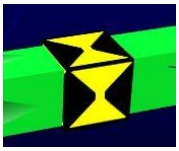
Yellow – fan operating in reverse

Red – fan stalled and air being forced backwards through fan

18.1.2 Blocked Airway

Blocked icons indicate an airway blockage or very high resistance has been placed and air cannot travel freely through the airway. Blocked resistance values are set in the preset menu. If blocked resistance values are above the maximum resistance specified in the Settings, then absolutely no airflow will be permitted along the airway.

18.1.3 Airway Resistance



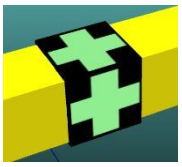
Indicates the presence of an airway resistance, above the normal airway resistance calculated from the size, shape and wall friction factors. An airway resistance normally represents an inputted resistance feature from the Edit Form, which may be a door, stopping or some other airway restriction.

Yellow – normal operating resistance setting with a preset value

Green – a custom resistance value entered specifically for that airway

Red – a preset resistance operating on a reversal resistance value, which has been activated by a reversing airflow and a 'restrict reversal' option specified for the airway in the EDIT form.

18.1.4 Fixed Airway



Fixed airflow placed in airway.

Green – once simulated, green indicates the fixed airflow is acting as a positive pressure, i.e. it is contributing towards overall pressure in the mine network

Red – once simulated, red indicates the fixed airflow is retarding normal airflow, and reducing pressure – i.e. it is acting as a resistance and contributing to overall pressure loss in the network.

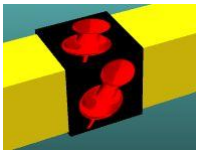
18.1.5 Fixed Pressure

Fixed pressure source placed in the airway.

Green –green indicates the fixed pressure is acting as a positive pressure, i.e. it is contributing towards overall pressure and flow in the mine network

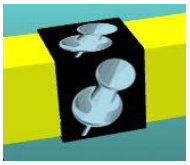
Red – red indicates the fixed pressure is negative and retarding normal airflow – i.e. it is acting as a resistance and contributing to overall pressure loss in the network.

18.1.6 Contaminant Report



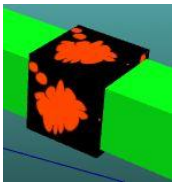
Indicates a contaminant report has been placed within the airway. A Contaminant Find simulation will use this report to indicate pathways of contaminants and potential sources of the contaminant.

18.1.7 Fresh Air Report



Indicates a fresh air report has been placed within the airway. A Contaminant Find simulation will use this report to indicate pathways of fresh air through the mine.

18.1.8 Contaminant

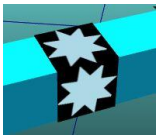


Indicates the presence of a contaminant in the airway. A contaminant simulation will predict the path and concentration of the contaminant downstream. A sourcing simulation will predict the paths and relative amounts of sourced air travelling to the airway.

18.1.9 Thermo-dynamic Heat or Moisture Source

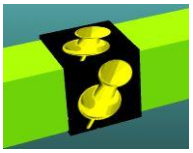
Indicates the presence of a positive heat or moisture source in the airway. A Thermodynamic simulation will mix the quantities and distribute the changes downstream. A **grey** colour indicates the preset heat or moisture has been turned off in the Edit box.

18.1.10 Thermo-dynamic Cooling or Drying Source



Indicates the presence of a negative heat source (cooling or refrigeration) or a moisture removing source in the airway. A Thermodynamic simulation will mix the quantities and distribute the changes downstream. A **grey** colour indicates the preset heat or moisture has been turned off in the Edit box.

18.1.11 Airway Notes



Indicates text notes have been made for the airway. Text notes can be viewed by clicked the airway with the Edit Form, and selecting the Notes Tab.

Chapter 19 APPENDIX D – Simulation Errors

The following messages may be shown if errors are present during network simulation. To select and view an airway with an error, simply click the error value in the Error List Box at the lower right corner of the screen.

19.1 Warnings

Warnings can generally be ignored, as the simulation will complete despite the warnings. They may however be a sign of a more serious problem, and should still be investigated.

19.1.1 no entry airway or surface connection

There is no airway entering the airway, therefore no airflow can be carried. The airway is not connected to the surface, marked as an open end, and Ventsim Visual™ cannot find a solution to reverse it. The program can be set to ignore these warnings in the Settings – Airflow Simulation menu.

Resolution Simply connect an airway to the entry, connect the airway to the surface, or marked as an open end in the Edit Box.

19.1.2 no exit airway or surface connection

As with no entry warning.

19.1.3 no entry or exit

As with no entry warning description.

19.1.4 airway stopping redundant

An airway stopping has been placed in series with another airway stopping. Only one stopping is required.

Resolution None required, although a stopping can be removed if desired.

19.1.5 fan directly interfering with another fan

A fan has been placed directly in series with another fan. The pressure imbalance between the fan curves may cause difficulty in resolve the network, partiulcarly if one fan is operating outside of its specified fan curve.

Resolution. Recommmend removing a fan, or ensuring an alternative airway path is available to help 'bleed' pressure between fans.

19.1.6 temperature balancing issue

Thermodynamic simulation is having difficulty resolving temperature balance between two airways. This may happen at extremes of temperature or pressure.

Resolution. Investigate what is causing high / low temperatures (eg high heat or refirgeration loads, coupled with low airflows). Resolve problem if possible. The Settings menu can be set to ignore this program, but this is generally not recommended.

19.1.7 stalled fan The fan is operating at too higher pressure / low volume, beyond the limits of the fan curve.

Resolution None required, however fans should not be made to run outside the curve. Ventsim Visual™ must 'guess' a result, which could lead to errors.

19.1.8 low pressure fan The fan is operating at too low pressure / high volume, beyond the limits of the fan curve.

Resolution. None required, however fans should not be made to run outside the curve. Ventsim Visual™ must 'guess' a result, which could lead to errors or air balancing issues. To remove the warning, increase the resistance the fan operates at, or extend the fan curve down to zero pressure.

19.1.9 negated fan The fan offering no additional pressure to the network, and may actually be retarding airflow.

Resolution. None required, however fans should not run as negated. Ventsim Visual™ must 'guess' a result, which could lead to errors or air balancing issues. In most cases, fan negation occurs as a result of other fans drawing air through the fan at a flow above the maximum fan curve quantity. To remove this warning, consider removing or switching off the fan.

19.2 Errors

Errors will generally halt a simulation process, and must be corrected before a valid simulation can occur.

19.2.1 airway attempted to reverse An airway set as 'restricted reverse' in the Edit box was attempted to be reversed by the simulation. As a result, the simulation is halted.

Resolution This function is designed to warn the user about airways which should not have reversed airflow. To remove this error, simply unclick the option in the Edit Box for the airway.

19.2.2 zero length airway An airway has been created with the same start and end point. This may occasionally happen when editing or creating airways.

Resolution Allow Ventsim Visual™ to delete the zerp length airway.

19.2.3 duplicate airway An airway with te same entry and exit location as another airway has been created.

Resolution Allow Ventsim Visual™ to delete the duplicate airway.

19.2.4 conflicting fixes and/or fans An airway has a fixed flow placed in line with another fixed flow, resulting in a conflict between the two flows.

Resolution Remove one of the fixed flows, or ensure a path between the flows exists to balanced the flow difference.

19.2.5 fix stopped An airway has a fixed flow placed where the air cannot travel through.

Resolution Check to ensure pathways before and after the fix are connected to the network or surface, and can freely flow air, and no blocked resistances are present in the pathways before or after the fix. Airways that are not exactly connected cannot carry airflow. While a no entry/exit warning will normally highlight these airways, if 'allow open end' has been selected, then no warning will show, and the problem may be difficult to find. Try the wireframe mode with nodes displayed if this is a problem.

19.2.6 operating fan blocked A fan has been placed in an airway through which no air can flow.

Resolution As with 'fix stopped', check to ensure restricting blocked resistances are not present, and the airways before and after the fan can carry air.

19.2.7 convergence problem The network cannot find a resolution in the network airflow balance.

Resolution Ensure fans are not running stalled or negated, and no unusual pressures or flows exist within the network.

19.2.8 temperature outside allowable range Temperature is increasing or being reduced beyond the allowable range.

Resolution Investigate what is causing high / low temperatures (eg high heat or refirgeration loads, coupled with low airflows). Ensure airflow is adequate for heat addition or removal amounts. Reduce heat input if possible, or increase airflow.

19.2.9 heat estimation error encountered A general error in estimating thermal properties occurred. This normally occurs where air temperatures or pressures are welll outside of the expected range.

Resolution Investigate what is causing high / low temperatures (eg high heat or refirgeration loads, coupled with low airflows). Ensure airflow is adequate for heat addition or removal amounts. Reduce heat input if possible, or increase airflow.

19.2.10 temp estimation near rock surface

An error estimate transfer of heat flux from rock strata surface to airflow. This may happen where unusually low airflow exist, or temperature or moisture values in the air are unusually high or low.

Resolution Increase airflow through airway, or increase tolerance of massflow setting in the Settings menu, to ignore airways with low flow.

19.2.11 overpressure across resistance

Pressure building up unacceptably over a high resistance airway, or a fan or fixed flow running into a high resistance airway. This error may occasionally show up when simulating Ventsim Classic 3.9 networks with Ventsim Visual.

Resolution Investigate and remove the source of the high pressure (fan or fix) or remove the high resistance causing the buildup in pressure. Unlike Ventsim Classic 3, which ignore this error, this situation is unacceptable to Ventsim Visual, as it adversely affects air densities and heat buildup, and in nearly all cases is a result of user input error. Pressure above 15000 Pa are generaly used as a trigger for this error.

19.2.12 operating fan restricted by resistance

A resistance has been placed in the same airway as a fan, and the fan is being unreasonably restricted. This is a common practise in Ventsim Classic 3.9 networks to stop airflow through a fan. In Ventsim Visual, it can cause overpressure and heat buildup, and is therefore no longer permitted.

Resolution Turn the fan OFF instead from the EDIT form, of remove the fan. If the fan is turned OFF, click on SELF CLOSING if you want to ensure air does not leak back through the fan.

19.2.13 fix being over restricted

Similar to overpressure across resistance, but the error code will target the airway with the fan or fix, not the resistance.

Resolution. Changing the fan or fix, or alternatively removing the high resistance will correct the problem.

19.2.14 unresolved pressure or flow

Ventsim Visual™ cannot resolve of pressure or airflow volume during simulation

Resolution Ensure no unusually airways, fan pressure or pathways exist within the network model.

19.2.15 fan static P curve invalid, check fan

No fan static pressure curve is available for the fan, but a static curve has been selected in the Edit Box or the Settings Menu.

Resolution Enter a fan static pressure curve for the fan, or ;

change the Edit Box setting to a Fan Total Curve (FTP), or ;

change the Global Fan Pressure method in the Settings menu to Total Pressure Method.

19.2.16 fan total P curve invalid, check fan

No fan total pressure curve (FTP) is available for the fan, but a total curve has been selected in the Edit Box or the Settings Menu.

Resolution Enter a fan total pressure curve for the fan or;

Change the Edit Box setting to a Fan Static Curve (FSP), or;

Change the Global Fan Pressure method in the Settings menu to Static Pressure Method.

Chapter 20 APPENDIX E – Shortcut Keys

A number of keyboard strokes exist to assist in rapid selection of commonly used functions. Most menu items have the shortcut key next to the menu item. Below is a general summary of common key strokes

CTRL N	**New File**
CTRL O	**Open File**
CTRL M	**Merge File**
CTRL I	**Inherit File Attributes**
CTRL S	**Save File**
CTRL F	**File Note**
CTRL C	**Clone Attributes**
CTRL V	**Apply Attributes**
CTRL L	**Lock On Target (Toggle)**
CTRL T	**Lock On Transparency (Toggle)**
CTRL Z	**Zoom Out**
CTRL Q	**Quick View**
LEFT Arrow	**Move to previous Quick View**
RIGHT Arrow	**Move to next Quick View**
HOME	**Fit All**
INSERT	**Insert Node**
PAGE UP	**Select / Move Up one elevation level (if defined)**
PAGE DOWN	**Select / Move Down one elevation level (if defined)**
END	**Show ALL elevation levels**
DEL	**Enter delete mode (select / fence airways to delete)**
BACKSPACE	**UNDO**
TAB - REDO	
F1	**HELP**
F2	**Plan / Section Views (Toggle to cycle through views)**
F3	**FIND (Toggle to repeat last find command)**
F4	**FIND and HIGHLIGHT found airways**
F5	**Simulation Airflow**
F6	**Simulation Thermodynamic**
F7	**Hide / Show Zero Flow airways**
F9	**Transparencies on/off**
F12	**Save As**
T	**Show / Hide text data**
L	**Show / Hide limited data**
Z	**Zoom Mode**
D	**Draw or Add airway mode**
E	**Edit Mode**
S	**Select Mode**
M	**Move Mode**
C	**Copy Mode**
B	**Block Mode (for blocking / unblocking airways)**
R	**Reverse Mode (for reversing airways)**
P	**Perspective / Orthogonal Mode Toggle**

W	**Toggle between Wireframe and Solids**
G	**Display / Hide Grid**
N	**Display / Hide Nodes**
A	**Display / Hide Arrows**
I	**Display Hide Icons**

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